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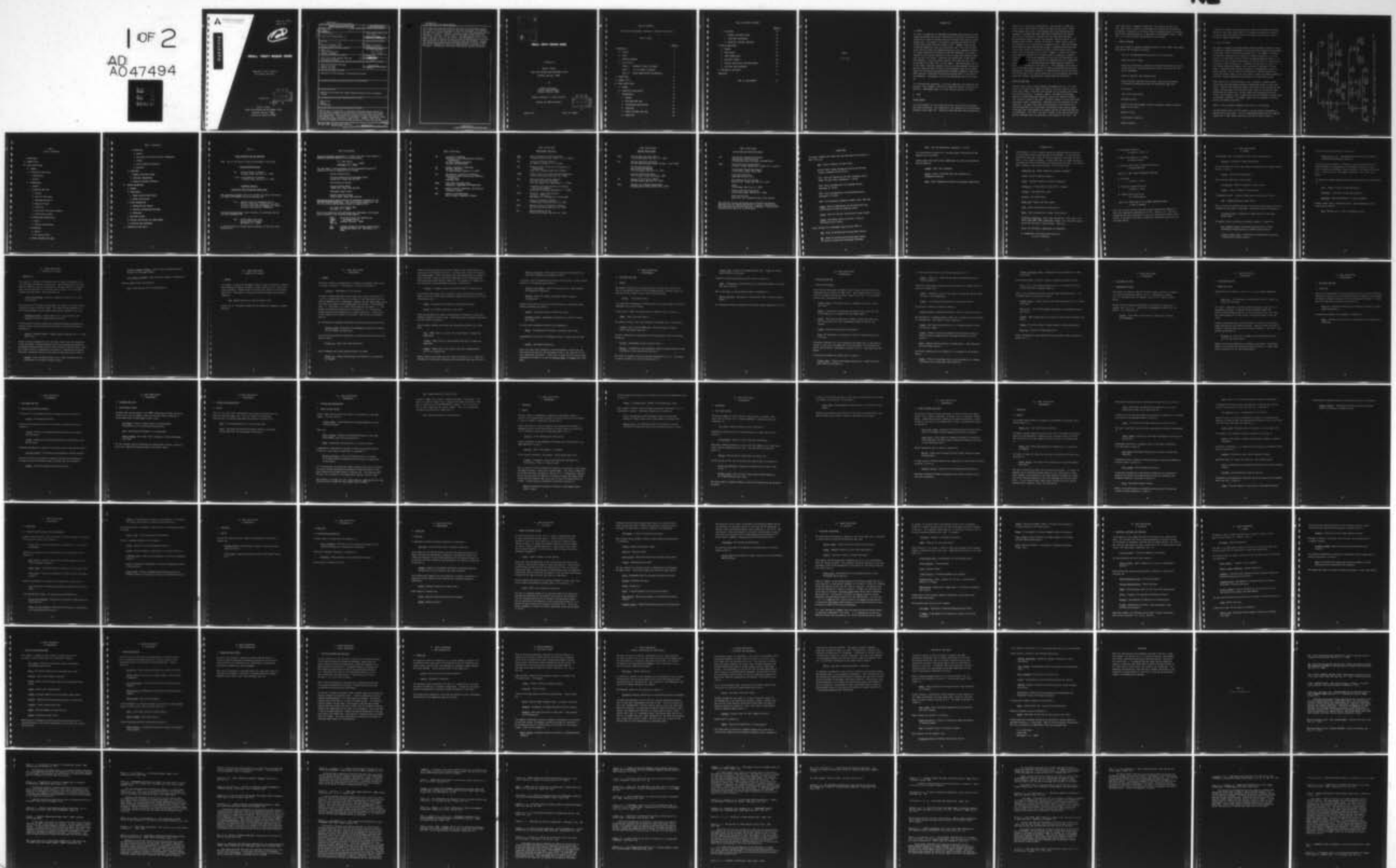

ASSET Incorporated
8550 ARLINGTON BLVD FAIRFAX VIRGINIA 22030
TEL (703) 573 3598 TELEX 89 9130

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B.S.

SMALL CRAFT DESIGN GUIDE

Prepared for

DAVID W. TAYLOR
NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
Bethesda, Maryland 20084
Contract No. N00167-76-M-8214

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This work is essentially an annotated bibliography which outlines for the practicing designer the current state-of-the-art of small craft design and engineering in terms of the most recent of the useful publications in each subject area. Its purpose is principally to update the previous "Guide to Power Boat Design" which was issued in 1971. However, there are two differences between this work and the previous one: First, the previous

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guide cited only about 100 references because it was a companion document to a rather extensive bibliography of over 1000 references. This guide is intended to be virtually complete in itself, citing older references whenever they are still useful. Therefore, the present work includes about 300 references. These are cited by author's last name and title only in the body of the text, Part I of this report. The Bibliography, Part II of this report, provides a complete listing, including document source and abstract, when available, for each of the references cited, but no others. Second, the previous guide presented some cautionary guidance in the use of model data and of oversimplified prediction methods which is not found in the references. Consequently, the earlier publications may still be useful.

SMALL CRAFT DESIGN GUIDE

Prepared for

DAVID W. TAYLOR

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Maryland 20084

by

ASSET Incorporated
8550 Arlington Boulevard
Fairfax, Virginia 22030

Joseph G. Koelbel, Jr., Naval Architect

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PART I, GUIDE

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PART I

G U I D E

INTRODUCTION

A. PURPOSE

This work is essentially an annotated bibliograhpy which outlines for the practicing designer the current state-of-the-art of small craft design and engineering in terms of the most recent of the useful publications in each subject area. Its purpose is principally to update the previous "Guide to Power Boat Design" which was issued in 1971. However, there are two differences between this work and the previous one: First, the previous guide cited only about 100 references because it was a companion document to a rather extensive bibliography of over 1000 references. This guide is intended to be virtually complete in itself, citing older references whenever they are still useful. Therefore, the present work includes about 300 references. These are cited by author's last name and title only in the body of the text, Part I of this report. The Bibliography, Part II of this report, provides a complete listing, including document source and abstract, when available, for each of the references cited, but no others. Second, the previous guide presented some cautionary guidance in the use of model data and of oversimplified prediction methods which is not found in the references. Consequently, the earlier publications may still be useful.

It is stressed that suggestions, criticisms, additions, and corrections are welcomed. These comments, and copies of additional entries should be submitted to: NAVSECNORDIV 6661, U.S. Naval Station, Norfolk, Va. 23511.

B. SCOPE

Subject Matter

This guide attempts to cover almost the entire field of naval architecture and marine engineering. The information in the references and the references' references nearly does this. There are a few areas which are not explicitly

covered, e.g. reliability, maintainability, and availability (RMA) and tests, trials, and evaluation (TT&E), but these are addressed in several of the general works cited. The headings under marine engineering are treated in less depth than those under naval architecture, not because they are less significant or because there are fewer published works, but because the practicing small craft designer selects an engine, as one example, from a catalog. He does not design it. Whole systems, such as refrigeration or air conditioning, are bought as units. Detailed coverage of the design of these machines and systems is therefore beyond the scope of this work, though an introduction to many of these subjects may be found in some of the general works cited. However, it should be stressed that a working knowledge of the system concepts is necessary in making a rational selection of system components to best suit the requirements, e.g. to decide whether the cooling (and possibly dehumidifying) of a compartment occupied by personnel and heat producing equipment should be handled by ventilation, refrigeration, heat pump, etc. This knowledge may be found in some of the general works cited such as "Marine Engineering" by Harrington. Nevertheless, the greatest emphasis is on the design of the form and structure of the craft's hull, and the prediction of its performance (resistance, propulsion, motions, accelerations) in both smooth and rough water.

Craft Size and Type

The term "small craft" is used frequently throughout the text. As it pertains to the scope of this guide, its meaning is not very specific and its limits are variable. The small craft designer can be concerned with almost any floating structure. In general, however, the amount of technology, especially recently developed technology, that must be applied increases with increase in speed of the craft. Therefore, emphasis on high speed (high performance) craft is appropriate. Regarding size, the boundaries are very indefinite. The upper limit seems to be determined by the combination of size and speed that still falls within the planing or semi-planing regime. A few years ago it was thought of as roughly 100 feet in length and 100 tons in displacement. The limit is now well in excess of 200 feet and 1000 tons, and the referenced works are being used in the design of such craft. The

term "small craft" is applied to them only in contrast to the term "big ship" which implies, generally, displacement hull technology, and which may be applied, in contrast, to a 125-foot, 600 ton coastwise tanker or freighter. Much of the referenced material is applicable to displacement vessels. Hydrofoils, air cushion vehicles and sailboats are not covered.

C. COMPUTER PROGRAMS

There are a number of computer programs available for use in small craft design. They perform the following calculations:

Bare Hull and Appendaged Resistance and Trim in Smooth Water

Added Resistance in Waves

Propulsion calculations as applied to inclined shaft propellers including the effects of induced pressures on the hull as well as lift and drag of appendages

Propeller selection from standard series

Impact pressures, pressure distributions, loads and accelerations, by theoretical methods and by means of experimental model data.

Ship motions

Lines fairing and lofting

Developed surfaces

Curves of Form (Displacement, Centers of Buoyancy, Metacentric Radius, Moment to Trim, etc.)

Bonjean's Curves

Cross Curves of Stability

Damaged Stability

In addition to making the calculations, the output can be plotted by machine. Sources for this work include some of the colleges or universities, some of the towing tanks, and certain firms or individual naval architects who specialize in computer applications.

D. USE OF THE GUIDE

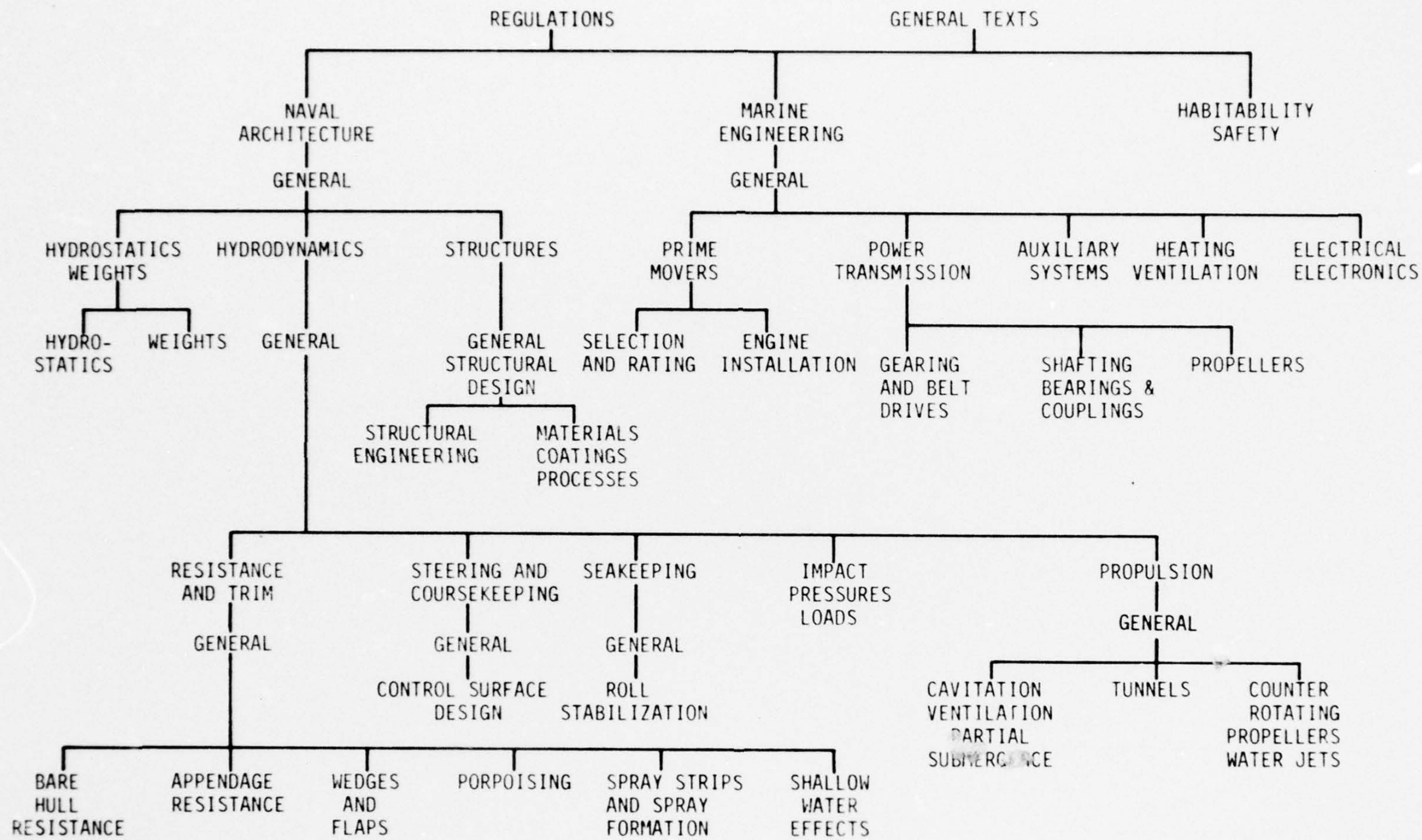
The guide is arranged so that each general subject category includes all works covering two or more sub-categories or works for which no specific sub-category is provided. Figure 1 shows this diagramatically. For example, in looking for pertinent references on the subject of cathodic protection, it will be noticed in scanning the listing of subject categories below that there is no category for, say, corrosion protection, and that Section IV.F, Electrical and Electronics, does not mention it. Therefore, the next place to look is in IV.A. Marine Engineering, General. Here one specific reference is listed, namely, "Impressed Current Cathodic Protection of Aluminum Hull Craft", by Miller and Hack. Also on the list of references is "Marine Corrosion" by LaQue, which should (and, in fact, does) have a section on cathodic protection. Similarly, "Marine Engineering" by Harrington is a good place to look.

After Section IV.A., the next place to look is Section II, General (which covers both naval architecture and marine engineering as well as other subjects). None of these references appears very likely to have anything on the subject, although books like "High Speed Small Craft" by Du Cane and "Naval Architecture of Planing Hulls" by Lord should be considered possibilities. Finally, the references cited in these works should be checked if greater depth of treatment is desired. For example, LaQue lists 20 references on various aspects of cathodic protection.

Table I lists the subject categories used in Part I of the Guide.

The Bibliography, Part II of this guide, lists the sources of documents by abbreviation in most cases. A list of these abbreviations with full name and address and of other sources that may be helpful is given in Table II.

FIGURE I. DIAGRAM OF SUBJECT CATEGORIES



Example: Information on "tunnels" may be found, not only under the heading "TUNNELS" but also under "PROPULSION, GENERAL" "HYDRODYNAMICS, GENERAL", "NAVAL ARCHITECTURE, GENERAL", and in both "REGULATIONS and "GENERAL TEXTS".

TABLE I.

SUBJECT CATEGORIES

I. REGULATIONS

II. GENERAL TEXTS

III. NAVAL ARCHITECTURE

A. GENERAL

B. HYDROSTATICS AND WEIGHTS

1. HYDROSTATICS

2. WEIGHTS

C. HYDRODYNAMICS

1. GENERAL

2. RESISTANCE AND TRIM

a. General

b. Bare Hull Resistance

c. Appendage Resistance

d. Wedges and Flaps

e. Porpoising

f. Spray Strips and Spray Formation

g. Shallow Water Effects

3. STEERING AND COURSEKEEPING

a. Genral

b. Control Surface Design

4. SEAKEEPING

a. General

b. Roll Stabilization

5. IMPACT PRESSURES AND LOADS

TABLE I (Continued)

6. PROPULSION

a. General

b. Cavitation, Ventilation, Partial Submergence

c. Tunnels

d. Counter-Rotating Propellers

e. Waterjets

D. STRUCTURES

1. GENERAL STRUCTURAL DESIGN

2. STRUCTURAL ENGINEERING

3. MATERIALS COATINGS, PROCESSES

IV. MARINE ENGINEERING

A. GENERAL

B. PRIME MOVERS

1. ENGINE SELECTION AND RATING

2. ENGINE INSTALLATION

C. POWER TRANSMISSION

1. GEARING AND BELT DRIVES

2. SHAFTING, BEARINGS AND COUPLINGS

3. PROPELLERS

D. AUXILIARY SYSTEMS

E. HEATING, VENTILATION, AIR CONDITIONING

F. ELECTRICAL AND ELECTRONICS

V. HABITABILITY AND SAFETY

TABLE II

SOURCE ABBREVIATIONS AND ADDRESSES

NOTE: Not all the sources listed are referenced in this guide.

CLASSIFICATION SOCIETIES

ABS	American Bureau of Shipping 45 Broad Street, New York, N.Y. 10004
Lloyds	Lloyds Register of Shipping 17 Battery Place, New York, N.Y. 10004

GOVERNMENT AGENCIES

EDUCATIONAL INSTITUTIONS AND TOWING TANKS

Many government documents which are available for public distribution are given an "AD Number" and may be obtained from:

NTIS	National Technical Information Service 5285 Port Royal Road, Springfield, Va. 22161 (Formerly called the Clearinghouse for Federal Scientific and Technical Information)

The Rules and Regulations listed in Section I as available from the USCG may be obtained from

USCG	United States Coast Guard Merchant Marine Technical Washington, D. C. 20590

or from the Officer in Charge, Marine Inspection, of the local Coast Guard District.

TABLE II(Continued)

Marine environmental protection as it affects the small craft designer is handled by the Coast Guard at the following address:

U.S. Coast Guard (   )
_____________________ Branch
Washington, D. C. 20590

The code number in the parentheses and the corresponding branch will depend on the area of responsibility as follows:

Overall responsibility:

Pollution Prevention and Enforcement Branch
(G-WEP-3/73) Phone (202) 426-9578

Certification of Devices:

Survival Systems Branch
(G-MMT-3/83) Phone (202) 426-1444

Enforcement (Small Craft):

Operator Compliance Branch
(G-BLC-3/TP42) Phone (202) 426-4176

Recreational Boating Safety Research and Development documents are also available from the Coast Guard. Most are available through NTIS. The list of available R&D RBS Reports should be requested from:

U.S. Coast Guard (G-DSA-2 RBS)
Washington, D. C. 20590

Much of the theoretical and experimental work referenced in this design guide originated in the following establishments:

NSRDC DTNSRDC DTMB TMB, EMB	David Taylor Naval Ship Research and Development Center Bethesda, Maryland 20084
NACA NASA	National Aeronautics and Space Administration 400 Maryland Avenue S.W., Washington, D. C. 20360

TABLE II (Continued)

UM	University of Michigan Department of Naval Architecture and Marine Engineering 445 West Engineering Building Ann Arbor, Michigan 48104
SIT DL	Stevens Institute of Technology Davidson Laboratory 711 Hudson Street, Hoboken, N.J. 07030
MIT	Massachusetts Institute of Technology Department of Naval Architecture and Marine Engineering Cambridge, Mass.
NSMB	Netherlands Ship Model Basin Haagsteeg 2, Wageningen, The Netherlands
NPL	National Physical Laboratory, Ship Division Teddington, England
AEW	Admiralty Experiment Works Haslar, Gosport, Hampshire, England

TABLE II(Continued)

PROFESSIONAL SOCIETIES

RINA INA	Royal Institution of Naval Architects 10 Upper Belgrave Street, London, S.W. 1, England
IME	Institute of Marine Engineers 85, Minories, London, E.C.3., England
NECI	North-East Coast Institution of Engineers and Shipbuilders Bolbec Hall, Newcastle-upon-Tyne, England
SNAME	Society of Naval Architects and Marine Engineers 1 World Trade Center, New York, N.Y. 10048
ASNE	American Society of Naval Engineers Suite 807, Continental Building 1012 14th Street, N.W., Washington, D. C. 20005
ASE	Association of Senior Engineers of the Naval Ship Systems Command Department of the Navy, Washington, D. C. 20360
SSCD	Society of Small Craft Designers c/o Carl J. Schnepf, Jr. 2656 Manker St., Indianapolis, Indiana 46203
SAE	Society of Automotive Engineers 2 Pennsylvania Plaza, New York, N.Y. 10001
ASME	American Society of Mechanical Engineers 345 East 47th Street, New York, N.Y. 10017
AWS	American Welding Society 345 East 47th Street, New York, N.Y. 10017

TABLE II(Continued)

INDUSTRY ASSOCIATIONS

ABYC	American Boat and Yacht Council 15 East 26th Street, New York, N.Y. 10010
BIA	Boating Industries Association 1425-401 North Michigan Avenue, Chicago, Illinois 60611
	The Aluminum Association Marine Aluminum Committee 750 Third Avenue, New York, N.Y. 10017
	American Plywood Association 1119 A Street, Tacoma, Washington, 98401
SPI	Society of the Plastics Industry 250 Park Avenue, New York, N.Y. 10017
NFPA	National Fire Protection Association 60 Batterymarch Street, Boston, Mass. 02210

TABLE II(Continued)

PUBLICATIONS AND PUBLISHING HOUSES

ISP	International Shipbuilding Progress International Periodical Press 194 Heenraadssingle, Rotterdam, The Netherlands
SBSR	Shipbuilding and Shipping Record 33 Tothill Street, Westminster, London S.W. 1., England
	International Marine Publishing Co. 21 Elm Street, Camden, Maine 04843
	Cornell Maritime Press Cambridge, Maryland 21613
	Motor Boating and Sailing Books 224 West 57th Street, New York, N.Y. 10019
	Rudder 1515 Broadway, New York, N.Y. 10036
	Yachting Publishing Corporation 50 West 44th Street, New York,N.Y. 10036
	Yachts and Yachting Eden Fisher Ltd., Southend-on-Sea, Essex, England

Note that many foreign publications may be obtained from American publishers such as International Marine, or Cornell Maritime Press, and from many large, and even some small, bookstores. There are also bookstores which specilize in marine books.

I. REGULATIONS

The codes, standards and regulations most applicable to the design of small craft are:

ABYC, "Safety Standards for Small Craft"

MIL-STD-1472B, "Human Engineering Criteria for Military Systems, Equipment and Facilities."

USCG, "Rules and Regulations for Small Passenger Vessels (Under 100 Gross Tons), Subchapter T," CG-323

USCG, "Rules and Regulations for Passenger Vessels, Subchapter H", CG-256

USCG, "Rules and Regulations for Uninspected Vessels, Subchapter C", CG-258

NFPA, "Fire Protection Standards for Motor Craft, NFPA 302"

Lloyds, "Rules and Regulations for the Construction and Classification of Wood and Composite Yachts"

Lloyds, "Rules for the Hull Construction of Steel Yachts"

Lloyds, "Provisional Rules for the Construction of Reinforced Plastic Yachts"

Useful guidance for displacement vessels can be found in:

ABS, "Rules for Building and Classing Steel Vessels"

ABS, "Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways"

USCG, "Load Line Regulations, Subchapter E," CG-176.

The classification societies will consider unusual construction or new materials on a case basis.

Several papers have been written commenting on the rules and regulations. Some of these are:

<u>Lippman</u>, "Small Craft Standards"

<u>Holtyn</u>, "Status of Aluminum Small Boat Standards and Recommended Practices"

<u>Brown</u>, "What's Happening with Marine Environmental Regulations"

II GENERAL TEXTS

The following is a list of general design and engineering texts which will be found useful by the practicing small craft designer. It also includes works which cover two or more of the below categories, and those for which there is not a specific category. In most cases they are simply representative works of a type of which there are several works available. For example, Marks' Handbook is well known but Kents' is also widely used.

Baumeister, ed., "Marks' Mechanical Engineer's Handbook"

Faires, "Design of Machine Elements"

Simon, "Engineer's Manual of Statistical Methods"

Traung, ed., "Fishing Boats of the World", 3 Volumes

Du Cane, "High Speed Small Craft"

Du Cane, "Fast Patrol Boats"

Boehe, Rolf, "Modern Fast Patrol Boats"

Lord, "Naval Architecture of Planing Hulls"

Meese, "Some Considerations in Power Cruiser Design"

University of Michigan, "Small Craft Engineering", notes used in the short course SMALL CRAFT ENGINEERING, October, 1971, have been reprinted and are available in three volumes. These are:

Report 120, RESISTANCE, PROPULSION, and SEAKEEPING

- Fundamentals of Resistance and Propulsion
  by Finn C. Michelson

- Performance Prediction
  by Joseph G. Koelbel, Jr.

- Small Craft Behavior in a Seaway
  by Daniel Savitsky

- Practical Application of Waterjet Propulsion
  by Howard Apollonio

Report 121, SMALL CRAFT ENGINEERING STRUCTURES

- Structures
  by Peter A. Silvia

- Fiberglass Reinforced Plastic
  by Robert J. Scott

- Aluminum Small Boat Design
  by C. Michalopoulos

Report 122, PROPULSION BY THE INTERNAL COMBUSTION ENGINE
by John B. Woodward

This last is one of the more authoritative and comprehensive summaries of small craft engineering technology as of 1971. Sections III.C. and III.D. provide the necessary references to bring it up to date (early 1977), particularly in the areas of resistance, propulsion, performance prediction, and structural design.

III. NAVAL ARCHITECTURE

A. GENERAL

The preeminent work in the general field of naval architecture is:

> Comstock, "Principles of Naval Architecture."

An excellent work that covers the subject with application to smaller vessels as well as ships is:

> Barnaby, "Basic Naval Architecture."

Works directed toward small craft include:

> Phillips-Birt, "Naval Architecture of Small Craft."

> Kinney, "Skene's Elements of Yacht Design."

A comprehensive work, covering a broad span of history up to 1968, is:

> Fox, "Seamanlike Sense in Power Craft."

There is much to be learned from this collection of designs many of which are intended for high speed in rough water. Additional views are expressed in:

> Silverleaf, Cook, "A Comparison of Some Features of High Speed Marine Craft."

The general subject, pertaining to advanced concepts, is covered in:

> Buck, Kennell, Fuller, "Performance Characteristics of High Performance and Advanced Marine (HIPAM) Surface Vehicles."

> Stevens, Carson, Krida, "Technological and Operational Constraints in Advance Marine Vehicle Design."

A more particular application is discussed in:

Ravenscroft, et. al., "Recommended Vehicle Concepts for Waterjet Propelled High Performance Vehicles."

A good collection of papers is contained in Occasional Publication No. 1, the Proceedings of the Symposioum on "Performance Prediction of Small Craft", edited by A. Millward. Papers included are: a)"Small Patrol Craft", by A. K. Sharples and b) "Performance Prediction - Fast Craft", by D. Bailey.

The questions of proper design, building, and other margins has been treated in:

Gale, "Margins in Naval Surface Ship Design."

Hockberger, "The Impact of Ship Design Margins."

Hockberger, "*Ship Design Margins* - Issues and Impacts".

Another current topic is designing to cost. Some information on this subject may be found in:

Sejd, "Marginal Cost - A Tool in Designing to Cost".

1. HYDROSTATICS

This subject is covered in the general works on naval architecture, which give the theory and methods of calculation. The following works cover standards of stability, that is, the question of how much stability is required. While each work pertains to a particular type of vessel, it is also good guidance for other types. These references are:

Sarchin and Goldberg, "Stability & Buoyancy Criteria for U.S. Navy Surface Ships"

The discussions of this paper are important, and relate it to other criteria, particularly those of the Coast Guard. This paper has been updated to include new developments such as Surface Effect Ships, Hydrofoils, etc., by

Goldberg and Tucker, "Current Status of U.S. Navy Stability and Buoyancy Criteria for Advanced Marine Vehicles"

A brief review of stability theory and a detailed calculation procedure for checking a boat's stability against the criteria of the above two papers is presented in:

Koelbel, "Procedures Manual - Dynamic Stability Analysis for U. S. Navy Small Craft".

Vessels carrying passengers for hire, and other vessels under the cognizance of the Coast Guard, including pleasure craft, are covered by publications of the Merchant Marine Technical Division, and the Office of Boating Safety. These are listed in Section I, Regulations, and Section V, Habitability and Safety. Additional information relating to the safety of small boats may be found in

Kennedy, "Static and Dynamic Stability of a Small Fourteen Foot Flat Bottom Boat as it Relates to Boating Safety"

Sauthulis, Bowman, Chadwick, "Level Flotation Standards Analysis Research and Development Report"

Gray, Blanton, Granholm, "Level Flotation, Research to Regulation"

Heavily loaded vessels are treated in

Hind, "Stability and Trim of Fishing Vessels".

III. NAVAL ARCHITECTURE

B. HYDROSTATICS & WEIGHTS

2. WEIGHTS

This subject is covered in the general works on naval architecture, including those covering the subject of margins, listed in Section III.A. "Naval Architecture, General". Weight control is of particular interest in high performance craft. The history of a particular high performance craft program is covered in

Pike, "Weight Control on a High Performance Craft"

Section III. D. "Structures" should also be checked for references on weight reduction.

III. NAVAL ARCHITECTURE
C. HYDRODYNAMICS

1. GENERAL

The overall subject of hydrodynamics is treated in the general works listed in Section II "General". The treatment is especially thorough in

Saunders, "Hydrodynamics in Ship Design"

This work, although published almost 20 years ago (9 years for Volume III), is still a valuable basic text on all aspects of ship hydrodynamics and contains an exhaustive list of references. However, the user should keep in mind that there are important recent developments, particularly in the following areas: 1) high speed, as it affects both propellers and rudders, 2) seakeeping and propulsion predictions for planing hulls, 3) low and intermediate speed resistance prediction for transom stern hulls. Current works on these subjects are included in this Guide. Some of the more important ones are:

For resistance and seakeeping predictions of planing and semi-planing craft:

Savitsky, Brown, "Procedures for Hydrodynamic Evaluation of Planing Hulls in Smooth and Rough Water".

For resistance and propulsion predictions, including cavitation data for many propeller types:

Blount, Fox, "Small Craft Power Prediction",

and its companion work (which replaces Blount, Carrinder)

Blount, Fox, "Design Considerations for Propellers in a Cavitating Environment"

These three works (and their references) summarize the state-of-the-art in planing craft performance prediction. The second gives a detailed procedure and worked example. These calculations have been computerized by a number of naval architects. Many of the reports referenced in this guide would have been impossible without computer capability. One example of a computer program developed to make performance prediction calculations is

Lutowski, "A Computer Program for Various Aspects of Planing Craft"

Two excellent works which are very helpful in making preliminary estimates of power, the first of which gives comparative propulsive data on many full scale planing boats, are:

Angeli, "Evaluation of the Quality of Planing Boat Designs"

Bailey, "Performance Prediction - Fast Craft"

There are many model test reports available which are helpful in making performance estimates of similar craft. Those which report resistance (and power) only are listed in Section C.2.

Several reports covering both smooth and rough water operations are listed here:

Chey, "Model Tests of a Series of Six Patrol Boats in Smooth and Rough Water"

Fridsma, "Model Tests of a Round Bottom Patrol Boat in Smooth and Rough Water"

Lueders, "Model Tests of Two Planing Forms and a Rounded Bottom Form in an Irregular Sea"

Reports covering rough water only are listed in Section III.C.4. Additional information on high speed displacement and round bottom boats may be found in

Marwood, Silverleaf, "Design Data for High Speed Displacement-Type Hulls and a Comparison with Hydrofoil Craft".

An overall view of transportation efficiency and the place of various marine vehicles in the spectrum may be found in

Gabrielli, Von Korman, "What Price Speed? Specific Power Required for Propulsion of Vehicles".

Davidson, "What Price Speed? Long Range Trends in Overseas Transportation".

General discussions of various hull design features as they affect hydrodynamic performance are given in

Koelbel, "The Detail Design of Planing Hull Forms".

Van Mater, Dornak, "Hydrodynamic Characteristics of Basic Planing Hull Types".

A similar work concerned principally with seakeeping is

McGown, "The Seaworthiness Problem in High-Speed Small Craft".

A comprehensive discussion of hydrodynamic design in general may be found in

Koelbel, "Performance Prediction".

which cites many useful references, providing guidance in their use, and which gives much practical and philosophical help in the selection of hull form, proportions and details. Those areas in which this 1971 work has been superseded are brought up to date by Savitsky, Brown, and Blount, Fox cited above.

2. RESISTANCE AND TRIM

a. General

The general references on resistance and trim are those which cover two or more of the detailed subjects in the following sections, and those which are not specifically covered in any of the following sections.

Hoerner, "Fluid Dynamic Drag."

is an exhaustive compendium of resistance data on many body shapes, projections, appendages and surface finishes.

A good source of model resistance data on a number of hulls is given in:

SNAME, "Small Craft Data Sheets."

The method of making a full scale prediction from model tests is described in:

Clement, "How to Use the SNAME Small Craft Data Sheets for Design and for Resistance Prediction."

The basic references for resistance and trim calculations in the full planing regime are:

Savitsky, "Hydrodynamic Design of Planing Hulls."

Shuford, "A Theoretical and Experimental Study of Planing Surfaces Including Effects of Cross Section and Plan Form."

The former is covered in Savitsky and Brown referenced in III.C.1. The latter is used as the basis of a practical design tool in

Clement, Pope, "Stepless and Stepped Planing Hulls - Graphs for Performance Prediction and Design."

A method for optimizing planing surfaces (hulls) is given in:

Hobbs, "Hydrodynamic Surface Selection for Optimum Performance in Planing Boat Power Selection."

Data on resistance in the pre-planing regime is presented in:

Mercier, Savitsky, "Resistance of Transom-Stern Craft in the Pre-Planing Regime."

This reference has been incorporated into Savitsky, Brown referenced in III.C.1.

2. RESISTANCE AND TRIM

b. Bare Hull Resistance

Aside from the calculation procedures, the principal sources of bare hull resistance data are reports of model tests. These always pertain to specific craft or to model series derived from a specific hull form. For hard chine planing hulls, good sources are:

Clement, Blount, "Resistance Tests of a Systematic Series of Planing Hull Forms."

Hubble, "Correlation of Resistance Test Results from Fixed- and Free-to-Trim Methods for a Dynamic-Lift Craft (Model 4667)."

Hubble, "Resistance of Hard-Chine, Stepless Planing Craft with Systematic Variation of Hull Form, Longitudinal Center of Gravity, and Loading."

Clement, "Analyzing the Stepless Planing Boat."

Brown, "An Experimental and Theoretical Study of Planing Surfaces with Trim Flaps."

The method of making a full scale prediction from model tests is described by Clement in "How to Use the SNAME Small Craft Data Sheets for Performance Prediction and for Design", referenced in Section III.C.2.a. Resistance and Trim, General.

A calculation procedure for planing hulls is given in:

Clement, Pope, "Stepless and Stepped Planing Hulls - Graphs for Performance Prediction and Design."

A similar work pertaining to very low aspect ratio hulls is:

Clement, "Graphs for Predicting the Ideal High-Speed Resistance of Planing Catamarans."

There are several reports pertaining to high aspect ratio planing surfaces as applied to stepped hulls:

Clement, "Performance Limits of the Stepless Planing Boat and the Potentialities of the Stepped Boat."

Clement, "A Lifting Surface Approach to Planing Boat Design."

Of particular interest for practical design is:

Lippisch, Colton, "Stepped Planing Boats, Some Full-Scale Test Results."

The advantages of a cambered planing surface can, in general, be utilized only in a stepped boat. Some reports on this subject are:

Clement, "The Planing Characteristics of a 15-Degree Deadrise Surface with Circular Camber."

Clement, "Graphs for Designing Cambered Planing Surfaces Having the Johnson Three-Term Camber Section, Rectangular Planform, and Zero Deadrise."

Moore, "Cambered Planing Surfaces for Stepped Hulls - Some Theoretical and Experimental Results."

A particular adaptation of the stepped hull is presented in the following reports:

Clement, "Effect of Length-Beam Ratio on the Performance of a Stepped Planing Boat with an Adjustable Stern Stabilizer."

Clement, Springston, Moore, "Hydrodynamic Design Procedure for a Dyna-plane Boat."

The following report is typical of many on inverted vee-bottom surfaces:

Kimon, P. M., "The Planing Characteristics of an Inverted V Prismatic Surface with Minus 10 Degrees Deadrise."

There is less information available on high speed, round bottom hulls. The following reports are particularly useful:

Marwood, Bailey, "Design Data for High Speed Displacement Hulls of Round-Bilge Form."

Yeh, H.Y.H., "Series 64 Resistance Experiments on High-Speed Displacement Forms."

Clement, "Merit Comparisons of the Series 64 High Speed Displacement Hull Forms."

Clement, "A Critical Review of Several Reports on Round Bottom Boats."

Beys, P.M., "Series 63, Round Bottom Boats."

Further information or round bottom hulls may be found in Chey, referenced in Section III.C.1.

2. RESISTANCE AND TRIM

c. Appendage Resistance

This subject is covered in some of the works listed in Sections II, General; III.A. Naval Architecture, General; III.C.1., Hydrodynamics, General; III.C.2.a Resistance and Trim, General; and III.C.3.b Control Surface Design.

Perhaps the most frequently quoted work on the subject of resistance is Hoerner, Sect. III.C.2.a . Scale effect on appendages in model tests is a problem. It is dealt with in:

> Clement, "Scale Effect on the Drag of a Typical Set of Planing Boat Appendages."

2. RESISTANCE AND TRIM

d. Wedges and Flaps

Information on this subject is very scarce. The best report obtainable is:

> Brown, P.W., "An Experimental and Theoretical Study of Planing Surfaces with Trim Flaps."

This report, summarized in Savitsky, Brown referenced in Section III.C.1. Hydrodynamics, General, is based on tests of prismatic models and presents readily useable equations for the calculation of the lift, drag, and trimming moment of the flap as well as the hinge moment of the flap itself.

Extensive experiments were run with two models of Series 62, with several wedge configurations and loading conditions. Apparently there has been no attempt to correlate these results with Brown's equations. This work is summarized and analyzed in:

> Millward, A., "The Effect of Wedges on the Performance Characteristics of two Planing Hulls."

Wedges can be used differentially to produce a roll moment. Experimental studies of this effect are presented by Denny and Block in a report referenced in Section III.C.4.b Roll Stabilization.

2. RESISTANCE AND TRIM

e. Porpoising

There are two experimental criteria for porpoising limits, given by Savitsky, referenced in Section III.C.2.a) Resistance and Trim, General, and by Clement and Blount, referenced in Section III.C.2.b) Bare Hull Resistance. A recent report on theoretical Prediction of Porpoising is:

> Martin, M, "Theoretical Prediction of Porpoising Instability of High-Speed Planing Boats".

An engineering approach to the subject is presented in:

> Angeli, "Evaluation of the Trim of a Planing Boat at the Inception of Porpoising".

2. RESISTANCE AND TRIM

f. Spray Strips and Spray Formation

A discussion of the importance and use of spray strips will be found in

Koelbel, "Performance Prediction"

Analytical and experimental work on the location of bottom spray strips is reported in

Clement, "Effects of Longitudinal Bottom Spray Strips on Planing Boat Resistance"

Clement, "Reduction of Planing Boat Resistance by Deflection of the Whisker Spray"

Background information on supression of the main spray blister may be found in:

Savitsky, Breslin, "On the Main Spray Generated by Planing Surfaces"

The results of full scale testing of several locations and configurations of spray strips on two different types of planing craft are reported in

Koelbel, "The Detail Design of Planing Hull Forms".

2. RESISTANCE AND TRIM

g. Shallow Water Effects

Although there are many papers in the SNAME Transactions and other sources on tunnel vessels such as towboats, there are very few current references on shallow water which are applicable to small craft.

> Christopher, "Effect of Shallow Water on the Hydrodynamic Characteristics of a Flat-Bottom Planing Surface."
>
> Toro, "Shallow Water Performance of a Planing Boat."
>
> Blount, Hankley, "Full Scale Trials and Analysis of High Performance Craft Data"

The last reference clearly establishes the minimum depth of water, relative to craft size, required to avoid any effect on the boat's speed.

3. STEERING AND COURSEKEEPING

a. General

There is still very little information on this subject aside from rules of thumb for selecting rudder area, listed in b) below, two references represent what is presently known about the steering of planing hulls:

Sugai, "On the Maneuverability of the High Speed Boat."

Henry, "Calm Water Equilibrium, Directional Stability and Steady Turning Conditions for Recreational Planing Craft."

III. NAVAL ARCHITECTURE

C. HYDRODYNAMICS

3. STEERING AND COURSEKEEPING

b. Control Surface Design

Several recent reports present the results of experiments on high speed rudders. The most useful is:

> Gregory, Dobay, "The Performance of High-Speed Rudders in a Cavitating Environment".

Others are:

> Mathis, Gregory, "Propeller Slipstream Performance of Four High-Speed Rudders under Cavitating Conditions".

> Moody, "Hydrodynamic Characteristics of a Control Surface:.

A comprehensive compilation of test data on many non-cavitating control surfaces of a wide range of proportions is presented in:

> Whicker and Fehlner, "Free Stream Characterisitcs of a Family of Low Aspect Ratio All-Moveable Control Surfaces for Application to Ship Design".

It is not necessary to use the many graphs presenting test results, because the authors present semi-empirical equations for the calculation of lift, drag, spanwise and chordwise center of pressure, etc. This paper has been the basis for virtually all the rudder and fin design in the U.S. Navy.

The following is an older, but still useful paper on rudder design with information on rules of thumb for sizing single and twin rudders.

Hall, "Rudder Design for Planing Craft".

A guide to rudder size is given in Gregory and Dobay, listed above. Also there is a graph of rudder size vs. overall boat length in Uffa Fox, referenced in Section III.A. Naval Architecture, General. It is not clear if this is total rudder area, or area per rudder. There is also some good information on selection of rudder area in:

Lord, "Naval Architecture of Planing Hulls".

III. NAVAL ARCHITECTURE

C. HYDRODYNAMICS

4. SEAKEEPING

a. General

The basic theory of seakeeping, as applied to displacement vessels, is covered in the standard works on naval architecture, particularly by Edward V. Lewis in Comstock, referenced in Section III.A.

A work, now mostly of historic interest, which explains the problems of seakeeping predictions for planing boats, and which contains an excellent list of references, particularly rough water model tests, is:

> Savitsky, "On the Seakeeping of Planing Hulls".

A good introduction to the seakeeping of planing hulls including their low speed operation is given in

> Savitsky, "Small Craft Behavior in a Seaway".

In this work he references, and presents sample design charts from

> Fridsma, "A Systematic Study of the Rough Water Performance of Planing Boats, Phase II, Irregular Seas".

This is currently the best information available on the motions, accelerations, and added resistance in head seas of planing boats. This work is summarized by Savitsky and Brown, referenced in Section III.C.1. Hydrodynamics, General, which also gives empirical equations for added resistance and impact accelerations which are based on and can be used in lieu of the design charts of Fridsma. A recent report on theoretical prediction of motions is:

> Martin, "Theoretical Prediction of Motions of High-Speed Planing Boats in Waves".

Excellent general discussions of the effects of hull form on seaworthiness may be found in:

McGown, "The Seaworthiness Problem in High Speed Small Craft".

and in papers by Koelbel and by Van Mater and Dornak, referenced in III.C.1. Hydrodynamics, General. Additional background is provided by:

Hires, "Recreational Craft Performance Study--Pitch and Heave Response of Three Planing Craft at Zero Speed in Following Seas".

Numata, Lewis, "An Experimental Study of the Effect of Extreme Variations in Proportions and Form on Ship Model Behavior in Waves".

4. SEAKEEPING

b. Roll Stabilization

The general subject of rolling and roll stabilization is covered in the works cited in Section III A. Current knowledge is summarized (citing 40 references) in:

Cox, Lofft, "State-of-the-Art for Roll Stabilizers."

Mathematical analysis and full scale experiments on a motor yacht are discussed in:

Van Gunsteren, "Analysis of Roll Stabilizer Performance."

Both these references present a case for using the rudders as roll stabilizers, either alone or combined with roll fins. Fin stabilizers are covered in detail in:

Conolly, "Rolling and its Stabilization by Active Fins."

and the testing of roll fins in two particular applications is discussed in:

Baitis, Cox, Wollaver, "Evaluation of Vosper Active Fin Roll Stabilizers,"

Shields, Foster, "Active Fin Roll Stabilization Effectiveness on a 65' Torpedo Retriever Boat (TRB)."

The latter report, although available for public distribution, may not be easily obtainable.

A study of roll control by means of flush flaps, located both at the transom and forward of the transom, is presented in:

Denny, Block, "Rolling Moment Characteristics of a Planing Hull with Wedges".

References pertaining to roll motions as they affect crew effectiveness and motion sickness may be found in Section V, Habitability and Safety.

5. IMPACT PRESSURES AND LOADS

The subject of impact pressures and loads is covered by Heller and Jasper, Danahy, Silvia, Spencer, and others in Section III.D.1, Structures, General Design. These works are easily useable by the practicing designer. Recent analytical work, which is at present useful in only a few specialized cases, is reported in:

> Gray, Allen, Jones, "Prediction of Three-Dimensional Pressure Distributions on V-Shaped Prismatic Wedges During Impact and Planing."

> Jones, Allen, "A Semi-Empirical Computerized Method for Predicting Three Dimensional Hull/Water Impact Pressure Distributions and Forces on High Performance Hulls."

Recent experimental Work on impact is reported in:

> Mercier, "Impact Loads on Warped Planing Surfaces Landing on Smooth and Rough Water."

A recent survey of slamming theories with suggestions for making them applicable to design is given in:

> Giannotti, Fuller, "Slamming of High Performance Marine Vehicles."

Additional references related to slamming will be found in Section III.D.2. Structural Engineering.

III. NAVAL ARCHITECTURE

C. HYDRODYNAMICS

6. PROPULSION

a. General

The current state-of-the-art in propulsion calculations is outlined, with a worked example, in:

Blount, Fox, "Small Craft Power Prediction".

This paper includes propeller characteristics over a wide range of cavitation numbers for the Gawn-Burrill propeller series, plotted in the K_T/J^2 format. The characteristics of other propeller series are given in the same format in:

Blount, Fox, "Design Considerations for Propellers in a Cavitating Environment".

The results of some full scale trials and their correlation with model tests are given in:

Blount, Hankley, "Full Scale Trials and Analysis of High Performance Craft Data".

This work is particularly useful for the practicing designer. It reports an apparent lack of correlation between model and full scale results in some areas; however, the discussions of the paper should be reviewed for explanations which bring the predictions into close agreement with the full scale trials. It also contains other useful design information such as plating pressures due to propeller forces, and strut design.

Round bottom propulsion factors, developed from model tests, are given in:

Blount, "Resistance and Propulsion Characteristics of a Round-Bottom Boat (Parent Form of TMB Series 63)."

A method of calculating the propulsive performance of planing craft, including most propeller and appendage effects is given in:

Hadler, "The Prediction of Power Performance on Planing Craft."

This work is applied to Series 62 with a wide range of propulsion arrangements in:

Hadler, Hubble, "Prediction of the Power Performance of the Series 62 Planing Hull."

Experimental data which is extremely useful in this type of prediction (inclined shaft) is given in:

Peck, Moore, "Performance Characteristics of Four Inclined Shaft Propellers."

A good description of propeller selection methods as applied to commercially available styles is given in:

Kress, Lorenz, "Marine Propeller Selection."

An excellent introduction to the design of propellers (as contrasted to selection from series) using both successful empirical techniques and acceptable theoretical principles is given in:

Kress, "High-Speed Propeller Design."

Reports of the performance of conventional ogive section (flat face and circular arc back) propellers is given in:

Gawn, "Effect of Pitch and Blade Width on Propeller Performance".

A somewhat more efficient series of propellers, having air-foil sections near the root and ogive sections near the tip, is reported in:

Van Lammeran, et.al., "The Wageningen B-Screw Series".

Results of tests on a series of propellers suitable for "transcavitating" operation (in both the sub- and supercavitating regimes as well as the transition from one to the other) are reported in:

Newton, Rader,"Performance Data of Propellers for High Speed Craft".

A refinement in the propeller selection procedure is discussed in:

Vibrans, "The Effects on Engine Load from Small Changes in Propeller Dimensions".

The effect of machinery, e. g. engine driven auxiliaries, on propeller performance is discussed in:

Woodward, "Propulsion by the Internal Combustion Engine".

Additional topics of interest are taken up in the following works:

Falls, "A Comparison of Contrarotating Propellers with other Propulsion Systems".

Van Manen, "Non Conventional Propulsion Devices".

Information on the operation of propellers behind the gearcase of an outboard motor lower unit is given in:

Kruppa, "Practical Aspects in the Design of High Speed Propellers".

Optimization of propeller design for a particular service is discussed in

Kroeger, Cummings, "Subcavitating Propeller Design for Maximum Propeller Efficiency or Minimum Fuel Use".

III. NAVAL ARCHITECTURE

C. HYDRODYNAMICS

6. PROPULSION

b. Cavitation, Ventilation, Partial Submergence.

Propeller characteristics over a wide range of cavitation numbers are plotted in the new, but useful, K_T/J^2 format in:

Blount, Fox, "Design Considerations for Propellers in a Cavitating Environment".

Cavitation performance of series propellers in the conventional format is reported in:

Gawn, Burrill, "Effect of Cavitation on the Performance of a Series of 16-inch Model Propellers".

Newton, Rader, "Performance Data of Propellers for High Speed Craft".

Peck, Fisher, "Cavitation Performance of Propellers with and without Cupping".

Cavitation performance in a tunnel hull configuration is dealt with in:

Peck, "Tunnel Hull Cavitation and Propeller Induced Pressure Investigation".

A few representative papers on supercavitating performance are:

Hecker, Peck, McDonald, "Experimental Performance of TMB Supercavitating Propellers".

Hecker, Shields, McDonald, "Experimental Performance of Controllable Pitch Supercavitating Propellers".

Cumming, "An Experimental Evaluation of three Methods for Increasing the Leading Edge Thickness of Supercavitating Propellers".

Ventilated propeller performance is dealt with in the following representative paper

Hecker, Crown, "Ventilated Propeller Performance".

Partially submerged propellers are discussed in:

Kruppa, "Testing of Partially Submerged Propellers".

Kruppa, "Practical Aspects in the Design of High Speed Propellers".

Lindenmuth, Barr, "Study of the Performance of a Partially Submerged Propeller".

Hecker, "Experimental Performance of a Partially Submerged Propeller in Inclined Flow".

Scherer, Bohn, "Partially Submerged Supercavitating Propellers-Parametric Analysis and Design of a Family of Nine Model Propellers".

6. PROPULSION

c. Tunnels

The two most recent and useful reports on performance of propellers in tunnels are:

Harbaugh, Blount, "An Experimental Study of a High Performance Tunnel Hull Craft."

Ellis, Alder, "Propulsion Experiments with a Deep Tunnel Planing Hull."

6. PROPULSION

d. Counter-Rotating Propellers

A recent report on counter-rotating propellers is:

Hecker, McDonald, "The Effect of Axial Spacing and Diameter on the Powering Performance of Counterrotating Propellers."

Additional background information is contained in:

Beveridge, "Thrust Deduction in Contra-Rotating Propellers."

See also Falls in Section III.C.6.a.

6. PROPULSION

e. Waterjets

A comprehensive review of waterjet propulsion is presented in

Apollonio, "Practical Application of Waterjet Propulsion"

which summarizes the state-of-the-art, describes the pumps available on the market, and gives the hydrodynamic fundamentals and mechanical design considerations necessary for the proper application of the waterjet concept. An earlier work that also provides a good background in the theory of propulsion by waterjet is

Brandau, "Aspects of Performance Evaluation of Waterjet Propulsion Systems and a Critical Review of the State of the Art".

The following work compares jets with propellers, discusses the matching of pump thrust to hull drag, and gives realistically attainable propulsive coefficients:

Arcand, "Waterjet Propulsion for Small Craft".

Other reports of interest are:

Kruse, "Waterjet Propulsion-Optimization Procedure".

Walker, "Marine Jet Units".

III. NAVAL ARCHITECTURE

D. STRUCTURES

1. GENERAL STRUCTURAL DESIGN

The structural design of small craft is covered in many general works on naval architecture and boat design. Some of these are listed in Sections II and III.A, and virtually all of them are listed by Silvia, referenced below. For wooden displacement boats the structural members are usually sized by previous experience. A great deal of this experience has been formalized in scantling rules such as those of Nevins and Herreshoff presented in

Kinney, "Skene's Elements of Yacht Design"

and in the rules and regulations of the classification societies listed in Section I (particularly Lloyds for yacht construction). There are also classification society rules for the construction of craft in fiberglass, aluminum and steel. Distinction must be made between yachts and commercial vessels when choosing scantlings according to a rule in order to get proper strength for the type of service the craft will experience.

The best general work giving a calculation procedure for small craft structures of both displacement and planing types, in all materials, is:

Silvia, "Small Craft Engineering Structures"

This work is important because of its excellent blend of the theoretical and practical approaches to the problem, and because of the exhaustive list of references pertaining to all materials including ferro-cement. The only reservation (now shared by Silvia and discussed below) is in regard to the basic bottom design pressure for planing hulls. Silvia currently recommends a synthesis of several other works listed and discussed in III.D.2.

Although directed primarily toward larger vessels, an excellent work which provides much useful information, especially structural details, applicable to craft built of steel or aluminum is the following:

D'Arcangelo, "A Guide to Sound Ship Structures".

Much valuable design guidance, based on actual boatbuilding experience, is provided by

Steward, "Boatbuilding Manual" (wood)

DuPlessis,"Fiberglass Boats"

Graul and Fry, "Design and Construction of Metal Planing Boats"

Klingle, "Boatbuilding with Steel"

The last contains an excellent section on "Boatbuilding with Aluminum" by Thomas Colvin. The following papers may also be of some interest:

Rukin, "Recommended Guide for Aluminum Crew Boats and Yachts"

Norgaard, "Aluminum Crew Boats"

Holtyn, "Alumability"

Rawat, "A Systems Approach to Hull Structural Design"

Gibbs and Cox, "Marine Survey Manual for Fiberglass Reinforced Plastics"

Caldwell, Hewitt, "Toward Cost Effective Design of Ship Structure".

Publications of Alcoa, Kaiser and Reynolds for aluminum and Owens-Corning for fiberglass are excellent sources of structural design information. In addition, some of the general works listed in Sections II, and III.A. cover construction. While not essential to the small craft designer, a general work which will provide him with a broad background and perspective on marine design in general (indluding construction and outfitting) is:

D'Arcangelo, "Ship Design and Construction:

An excellent recent work on the design of structures with a view toward weight saving is:

Heller, Clark,"The Outlook for Lighter Structures in High Performance Marine Vehicles".

III. NAVAL ARCHITECTURE

D. STRUCTURES

2. STRUCTURAL ENGINEERING

The structural design process as applied to small high speed craft is outlined in several works of which the following are most used:

Heller, Jasper, "On the Structural Design of Planing Hulls"

Danahy, "Adequate Strength for Small High Speed Vessels"

Spencer, "Structural Design of Aluminum Crew Boats"

These papers, and the Silvia paper referenced in III.D.1, all use different basic hull design pressures. This problem is partially resolved for very high performance craft by the presentation of the results of some fairly extensive full scale trials in

Allen, Jones, "Considerations on the Structural Design of High Performance Marine Vehicles"

There is, however, no one accepted method for arriving at design loads or accelerations nor is there general agreement as to factors of safety or allowable stress and defection limits once the loads are selected. The designer must decide how conservative a design is required. If model test derived acceleration data are available, the Allen, Jones method may be used to determine design pressure. Lacking model test data, the Spencer equations provide reasonable calculated design pressures for most applications. For very fast craft, it is suggested that a check be made of the Spencer derived pressure by working the Allen,Jones method backward to ensure that unnecessarily high acceleration levels are not being accommodated.

It is very important to remember that each design pressure estimation method is completely independent of the others. It is inappropriate to apply the reduction factors from one method to the initial pressure derived by another.

As stated, all the above papers are concerned primarily with the determination of a suitable design pressure for each of the major structural elements of the hull. For a detailed stress analysis of a particular structure, any of the many standard textbooks may be used. For example:

Timoshenko, "Elements of Strength of Materials"

Roark, "Formulas for Stress and Strain"

Stress analysis is, of course, a field in itself and coverage of more advanced methods is beyond the scope of this work. Additional works which will be found useful are:

United States Steel, "Design Manual for High Strength Steels"

Kaiser Aluminum, "Aluminum Boats"

Alcoa, "Aluminum Afloat"

Lincoln Electric, "Procedure Handbook of Arc Welding"

Bureau of Ships, "Wood: A Manual for its Use as a Shipbuilding Material", 4 Volumes

Owens-Corning, "Boatbuilder's Answer Book", a collection of technical publications.

A great deal of other valuable technical information is published by the various trade associations.

The following works may also be of interest:

Lev, Nappi, "Properties of Combined Aluminum Beam and Plate"

El Gammal, "A New Method for Estimating the Fatigue Life of Ship Structures"

Demchik, "Marine Environment Effects on Fatigue Crack Propagation in GRP Laminates for Hull Construction"

Noonan, "An Assessment of Current Shipboard Vibration Technology"

Furio, Gilbert,"Energy Absorption and Impact Behavior of Stiffened and Unstiffend Aluminum Panels"

Smith, "Buckling Problems in the Design of Fiberglass Reinforced Plastic Ships"

3. MATERIALS, COATINGS, AND PROCESSES

The properties of most common materials can be found in the standard handbooks. For aluminum, the various aluminum companies are the best sources. For information on fiberglass, the best source is Owens-Corning. For steel, a work that has been found very useful, particularly for its description of steel alloys, their application, properties, etc., is:

Lincoln Electric, "Procedure Handbook of Arc Welding"

For wood properties one of the best sources is

Bureau of Ships, "Wood: A Manual for its Use as a Shipbuilding Material"

Other publications covering various aspects of materials, coatings and processes are:

American Welding Society, "Hull Welding Manual"

American Welding Society, "Welding Aluminum"

SNAME, "Coating Systems Guide for Hull, Deck and Superstructure"

Gelfer, "Inorganic Zinc Coatings on Underwater Surfaces"

Marshall, "Shop Approach to Fabrication of Aluminum Boats"

Klingle, "Boatbuilding with Steel" (including Colvin, "Boatbuilding with Aluminum")

Additional guidance and references may be found in some of the general works cited in Sections I, II, III.A., and IV.A.

IV. MARINE ENGINEERING

A. GENERAL

The general subject of marine engineering is covered in several of the works listed in Section II, "General", and in

Harrington, "Marine Engineering"

This work is an authoritative summary of the entire field and includes many references which will be found useful in particular applications.

The following works on specific subjects are not included in any of the following subsections:

Jacob, Hawkins, "Elements of Heat Transfer"

Solberg, Cromer, Spaulding, "Thermal Engineering"

Lundgaard, "The Relationship Between Machinery Vibration Levels and Machinery Deterioration and Failures"

Lundgaard, Grant, "New Methods of Vibration Analysis and Stress Measurement in Rotating Machinery"

Wilson, Lombardi, "Interim Procedure for the Calculation of High Performance Ship Endurance Fuel Requirements"

The most authoritative and current work on the subject of marine corrosion is

LaQue, "Marine Corrosion"

A particular aspect of the subject is covered in:

Miller, Hack, "Impressed Current Cathodic Protection of Aluminum Hull Craft"

An excellent work covering the whole field of engine selection, rating, installation and interaction with propulsors and auxiliaries is:

<u>Woodward</u>, "Propulsion by the Internal Combustion Engine"

Although it concerns a particular class of vessel, the following work is of general interest

<u>Lundgaard, Mathers</u>,"PGM Class Aluminum Gun Boat Machinery and Controls"

An excellent introduction to the theory of propulsion control systems and its practical application is given in:

<u>Rubis</u>,"Acceleration and Steady-State Propulsion Dynamics of a Gas Turbine Ship with Controllable-Pitch Propeller"

The methods described in this work are readily applicable to small craft design.

IV. MARINE ENGINEERING

B. PRIME MOVERS

1. <u>ENGINE SELECTION AND RATING</u>

This subject is covered in works listed in Sections IV.A. and II. In addition, the following works are of particular interest

<u>Barr, Etter</u>, "Selection of Propulsion Systems for Advanced High Speed Marine Vehicles"

<u>McCoy</u>, "Gas Turbine Propulsion for High Speed Small Craft"

<u>McAnally</u>, "Small Turbine Engine Technology"

<u>Benham</u>, "State of the Art Review, Small Gas Turbine Engine Technology"

<u>Sawyer</u>, "Sawyer's Gas Turbine Catalog"

<u>Femenia</u>, "Economic Comparison of Various Marine Power Plants"

<u>Henshall</u>, "Medium and High Speed Diesel Engines for Marine Use"

<u>Schrader</u>, "Diesel Engine Design Study"

<u>Wagner</u>, "Rational Methods for Engine Ratings"

<u>Wyland</u>, "Selection of Power Plants"

Good sources of information on engine selection and rating are the installation manuals of the engine manufacturers, some of which are listed in Section IV.B.2.

2. ENGINEERING INSTALLATION

The best source of information on the many details of engine installation, including not only mounting but all auxiliary systems are the installation manuals of the various engine manufacturers. Some of these are:

Caterpillar, "Marine Engine Application and Installation Guide"

Detroit Diesel Allison Division, General Motors, "Marine Engine Information"

Pratt and Whitney, "P and W FT4 Gas Turbine Installation Design Handbook"

General Electric, LM2500 Marine Gas Turbine Installation Design Handbook"

AVCO Lycoming, "Applications Handbook"

Little information is currently available on the design of heat exchanger systems for small craft. Two of the best works are

Graul, "Fresh Water Cooling for Marine Engines"

Baier, Schubert, "Skin Cooler Design"

A specialized work bearing on installation practices is

Weber, Schenck, "A Biological Assay of the Effects of Submerged Engine Exhausts"

IV. MARINE ENGINEERING

C. POWER TRANSMISSION

1. GEARING AND BELT DRIVES

The small craft designer's interest in gearing and belt drives is usually limited to engineering information required for the selection and installation of a particular unit. Manufacturer's catalogs and applications handbooks are usually adequate.

Gear design information in sufficient detail for sizing gear trains not available off-the-shelf is available in standard mechanical engineers handbooks such as Marks, and in the references they cite.

IV. MARINE ENGINEERING

C. POWER TRANSMISSION

2. SHAFTING, BEARINGS AND COUPLINGS

Design information for the selection of shaft sizes and bearing spacing can be found in mechanical engineering handbooks, general works on naval architecture and marine engineering, codes and standards of the American Boat and Yacht Council, the American Bureau of Shipping and other agencies, publications of some of the shafting manufacturers, e.g., Huntington Alloy Division of International Nickel Co., Armco Steel Corporation, and other sources. Some of these are listed in Sections I, II, III.A, and IV.A above.

Most of the required data for the selection of bearings and couplings can be found in manufacturers catalogs. Engineering and design data are available from the sources listed above.

The Society of Automotive Engineers (SAE) standard taper has long been the industry standard for propeller shafts. It may be supplanted by the ISO standard and developments in this area should be followed. The Boating Industry Association (BIA) is in touch with these matters. As a matter of practical design, the SAE taper is not suited to the new high strength shafting materials because they have a higher ratio of strength to modulus. Therefore the tapered part of the shaft, in the propeller, twists more than it does with weaker materials, thereby letting the forward part of the key carry much of the torque load. This results in cracking around the forward end of the keyway. This can be alleviated by grinding out the keyway to eliminate sharp corners at its forward end.

IV. MARINE ENGINEERING

C. POWER TRANSMISSION

3. PROPELLERS

The mechanical aspects of propellers, e.g., blade strength, vibration, etc., are generally well taken care of in the design of the most frequently used blade sections, and the small craft designer is therefore seldom concerned with these problems. Two of the best works on the subject are:

O'Brien,"The Design of Marine Screw Propellers"

Conolly, "Strength of Propellers".

The references cited in Sections III.A and IV. A. should also be consulted. The choice of materials is covered in these works. In addition, the larger propeller manufacturers can provide valuable assistance in this matter.

Controllable-pitch propellers, aside from the selection of their hydrodynamic characteristics, are beyond the scope of this work.

IV. MARINE ENGINEERING

D. AUXILIARY SYSTEMS

Most of the design information required for sizing the capacity or capability of auxiliary systems and for the selection of components can be found in mechanical and other engineering handbooks, general works on naval architecture, marine engineering and ship design, the publications of the classification societies and other agencies, and other works, some of which are listed in Sections I, II, III.A, and IV.A.

Some excellent literature on the design of systems is available from the manufacturers. For example:

Vickers, "Vickers Industrial Hydraulics Manual"

Crane Co., "Flow of Fluids"

There are also many papers on auxiliary system design. A few of these are:

Wallin, "Marine Sewage Treatment Plants - A Guide to Selection"

Woodward, "Arrangement of Shipboard Piping by Digital Computer"

Woodward, "Waste Heat Distillers in Small Craft - Some Engineering Considerations"

Environmental regulations are now an important consideration in the design of auxiliary systems, for example, the need to include oil separators in the discharge piping of the bilge system, or ash traps in a dry exhaust system. A work on this subject is:

Weber, Schenck, "Biological Assay of the Effects of Submerged Engine Exhausts".

IV. MARINE ENGINEERING

E. HEATING, VENTILATION, AIR CONDITIONING

The basic principles of heating, ventilation, and air conditioning are the same for small craft as for large ships and the texts and methods used for the latter are, in general, applicable to the former. For example the general texts and engineering handbooks cited in Sections II, II.A., and IV.A provide a good starting point.

Harrington, "Marine Engineering"

in particular, presents a good introduction to environmental control systems including basic calculation precedures such as heat load, required volume and distribution of ventilation air, duct losses, etc. The references cited provide an in-depth coverage of the subject.

Environmental aspects of this subject are covered in:

Karanzalis, "Heating, Ventilating, Air Conditioning and the Environment".

The codes and regulations cited in Section I provide additional guidelines and, in some cases, requirements which must be met. In the final design of the craft, manufacturers' literature must be used to select the actual hardware to be installed. The functions of heating, ventilating and air conditioning are handled most efficiently in larger craft by central plants. In smaller craft sizes it is frequently better (considering space and cost as well as, or perhaps more than, power consumption) to use small self-contained units rather than a central system. The cross over size is about 70 feet LOA for types of craft devoted mostly to habitable spaces.

IV. MARINE ENGINEERING

F. ELECTRICAL AND ELECTRONICS

The principal sources of information in this field are the general texts, engineering handbooks and codes cited in Sections I, II, III.A., and IV.A. above, plus the references they cite. The principles, of course, pertain to every situation, but in most cases the above references are directed toward applications in larger, heavier and more complicated systems. For the designers of the smaller craft the most applicable of these references are the ABYC Safety Standards, and applicable sections of the National Electrical Code, and the Fire Protection Standards for Motor Craft, NFPA 302, authorized by the National Fire Protection Association.

One of the best general works covering basic principles, operation and installation of electrical systems aboard small craft is

Miller, "*Your Boat's Electrical System*"

Although intended for the layman, it is also an excellent primer for the designer who is not familiar with electric systems. Another excellent work of a more technical nature which offers great assistance in the basic design of a system (e.g., AC vs. DC, electric load analysis, choice of emergency power source) is

Woodward, "Electric Power for Small Commercial Vessels"

Another paper of interest is

Powell, "Electrical Installation in Fishing Vessels"

The installation of electronics equipment aboard small craft has received little attention in the technical literature, and is a matter of

choosing and installing equipment. The owner or operator frequently knows what equipment he wants to install. Manufacturers' literature and technical assistance must be relied upon. In addition, the actual installation work must be done by a licensed technician. Articles in the magazines of the pleasure boating, work boat and fishing fields are frequently helpful. An excellent introduction to the subject may be found in

Miller, "Your Boat's Electrical System", cited above.

An important consideration in the layout of electrical and electronic equipment aboard a boat is electromagnetic interference. This influences not only the construction, bonding and shielding of equipment and cables but also the relative placement of equipment, particularly antennas. Unfortunately, most of the references on this subject are from military sources and limited in their distribution. The designer of small craft should simply be aware of these problems and enlist the help of the electronics people he deals with in preventing unwanted mutual interference.

V. HABITABILITY AND SAFETY

The general subject of space allocation, clearances and other dimensional requirements for the comfort, convenience or efficiency of personnel aboard the craft are covered in general works on naval architecture and small craft design some of which are referenced in Sections II and III.A. In addition, there are requirements for Navy craft and craft to be certificated by the Coast Guard which are outlined in publications referenced in Section I.

Safety standards encompass most of the systems and these, too, are covered by the references of Section I. An interesting paper on the subject is:

> Momany, "Design Guidelines for Pressure Relief Flame Deflectors for I-O Boats"

Current interest in habitability centers primarily in the reduction of hull impact accelrations (for high speed craft), vibration, and noise. Impact has been covered in Section III.C.5. Its effect on personnel is treated in

> Wolk, Tauber, "Man's Performance Degradation During Simulated Small Boat Slamming"

Human tolerance of vibration is covered in

> Bender and Collins, "Effects of Vibration on Human Performance, a Literature Review"

> Reed, "Acceptable Levels of Vibration on Ships",

which presents the ISO standards, and

> Von Gierke,"Shock and Vibration Bulletin 45, Part 2",

which presents limits based on a 1/3 octave band RMS analysis of the vibrations.

Noise control is covered in the following publications:

Douglas, Kenchington, "Mechanical Impedance Techniques in Small Boat Design"

Lewis, Snuggs, "Airborne Noise Control as Applied to High Performance Craft"

Dyer, Lundgaard, "Noise Control on Diesel Tugs"

Schiff, "Case Histories of the Silencing of Marine Gas Turbines"

NAVSHIPS, "General Criteria for Ensuring Quiet Gas Turbine Shipboard Installation"

MIL-STD-740, "Airborne and Structureborne Noise Measurements and Acceptance Criteria of Shipboard Equipment"

A recent work on human tolerance of boat motions is

Payne, "A Note on Roll Stabilization and Crew Efficiency"

Safety of personnel at sea is discussed in

Sweger, "What Have You Done for the Fleet Sailors Life Today?

A broad spectrum of documents pertaining to recreational boating safety are available from the U. S. Coast Guard. Most of them are available through NTIS. The list of available R & D RBS Reports should be requested from

U. S. Coast Guard
G-DSA-2 RBS
Washington, D. C. 20590

CONCLUSION

While this Design Guide truly represents the state of the art in small craft design as of January 1977, it is entirely possible, even probable, that several significant recent papers have been omitted. Because of this possibility, it is suggested that the reader doing an exhaustive study of a particular area check recent listings of the publications of all likely sources, many of which are listed in the introduction. The references and sources will lead from one to another, and finally to the researchers and practitioners in the field, so that any desired depth, or breadth, of knowledge may be obtained.

PART II

B I B L I O G R A P H Y

A

ABS, "RULES FOR BUILDING AND CLASSING STEEL VESSELS", American Bureau of Shipping, 45 Broad Street, New York, N. Y. 10004.

ABS, "RULES FOR BUILDING AND CLASSING STEEL VESSELS FOR SERVICE ON RIVERS AND INTRACOASTAL WATERWAYS", American Bureau of Shipping, 45 Broad Street, New York, N.Y. 10004.

ABYC, "SAFETY STANDARDS FOR SMALL CRAFT", American Boat and Yacht Council, 15 East 26th Street, Room 1603, New York, N.Y. 10010. Revised every year.

ALCOA, "ALUMINUM AFLOAT", 1964, Aluminum Company of America, Literature Inquiry Services, 1256 Alcoa Building, Pittsburg, Pa. 15219.

Allen, R.G., and Jones, R.R., "CONSIDERATIONS ON THE STRUCTURAL DESIGN OF HIGH PERFORMANCE MARINE VEHICLES", N. Y. Metropolitan Section, SNAME, January 1977.

Discussed are structural trials data from several planing hulls and one high length-to-beam ratio, surface effect ship. The collected data are used to modify several well-known methods for predicting hydrodynamic loadings and structural response of planing hulls, hydrofoils, air cushion vehicles, and surface effect ships. The merits and weaknesses of these and other less well-known methods are discussed. Simplified methods, developed by the authors, are presented for determining design-limit pressures for hydrofoils, air cushion vehicles, and surface effect ships which should produce consistent, yet not overly conservative, results.

American Welding Society, "HULL WELDING MANUAL", 345 East 47th Street, New York, N. Y. 10017.

American Welding Society, "WELDING ALUMINUM", 345 East 47th Street, New York, N. Y. 10017.

Angeli, J.C., "EVALUATION OF THE QUALITY OF PLANING BOAT DESIGN", SNAME Southeast Section, February 18, 1971.

The purpose of the present paper is to provide planing boat designers with a straightforward method for the comparison of boat performance whatever the displacement and speed might be, and similarly, to evaluate the probable merit of a project at an early stage of the design.

Angeli, J.C., "EVALUATION OF THE TRIM OF A PLANING BOAT AT INCEPTION OF PORPOISING", SNAME Spring Meeting April 1973.

Planing boats porpoise in smooth water when the angle of attack, or trim of the planing surface exceeds a critical value that depends on the speed, on the configuration of the hull and on the location of the center of gravity. The purpose of the present paper is to provide designers with a straightforward method for the evaluation of the critical trim corresponding to a given set of conditions.

Numerical applications show that the trims so computed agree with experimental results within acceptable limits.

Apollonio, H., "PRACTICAL APPLICATION OF WATERJET PROPULSION", Part of University of Michigan, "SMALL CRAFT ENGINEERING", Report 120.

Arcand, L., "WATERJET PROPULSION FOR SMALL CRAFT", SNAME, Southeast Section, May 1966.

In this paper, the results of a study of the application of waterjet propulsion to small planing boats are reviewed. The boats ranged in length from 23 to 52 feet and were powered to operate at design speeds from 20 to 40 knots. At design speeds of about 30 knots and higher, the installed performance of waterjets was found to be better than that of propellers. The reduction in drag due to elimination of underwater appendages is the most significant performance advantage of waterjets. Also discussed is the effect of pump cavitation on propulsion performance and machinery damage.

AVCO Lycoming Division, "APPLICATIONS HANDBOOK FOR TF (TWO SHAFT) AND TC (SINGLE SHAFT) GAS TURBINE ENGINES - MARINE & INDUSTRIAL USE".

B

Baier, L.S., and Schubert, J., "SKIN COOLER DESIGN", SNAME, Pacific Northwest Section, April 1962.

Bailey, D., "PERFORMANCE PREDICTION--FAST CRAFT", National Physical Laboratory Report Ship 181, October 1974, also RINA, Small Craft Group, London, November 1974.

Fast craft discussed here are those which operate in a Froude number range of 0.3 - 1.5 ($V/\sqrt{L}$ = 1.0 - 5.0) and which can be of displacement or planing hull type. The faster derivatives of the latter such as the racing boat are considered to be outside the scope of the present paper.

Predicting the performance of fast craft at an early design stage will demand reliable estimates of the power requirements for a given calm water speed as well as some idea of the handling characterisitcs of the proposed design. This paper presents data, largely developed from model experiments, and methods of prediction are given together with the effect on performance of varying such parameters as waterline beam and longitudinal center of buoyancy. Devices such as spray rails and transom wedges used in refining a particular design are discussed, and manoevring and seakeeping aspects considered.

Baitis, A. E., Cox, G. G. and Woolaver, D., "THE EVALUATION OF VOSPER ACTIVE FIN ROLL STABILIZERS", Third Ship Control Systems Symposium, Sept. 1972.

Barnaby, K. C., "BASIC NAVAL ARCHITECTURE", John de Graff, Inc. 34 Oak Avenue, Tuckahoe, N. Y. 10707, 1960.

Barr, R. A., Etter R. J., "SELECTION OF PROPULSION SYSTEMS FOR HIGH-SPEED ADVANCED MARINE VEHICLES", SNAME, Marine Technology, January 1975.

Methods and criteria for evaluating and selecting propulsion systems for high-speed marine vehicles such as surface effect ships, hovercraft, hydrofoils, and planing craft are summarized. The problem of matching ship performance (drag, thrust, endurance, etc.) and geometric requirements to propulsion system characteristics to select the best propulsion system for a given application is discussed in some detail. Water-jet, marine propeller and air propulsion systems, including propulsor, propulsor mounting appendages, transmission and engines, are considered. An example utilizing a 4000-ton surface effect ship illustrates that the numerous tradeoffs

involved in the selection process may lead to a propulsion system selection based on parameters other than propulsive efficiency. A second example for a 750-ton hydrofoil craft is referenced.

Baumeister, ed., "MARK'S MECHANICAL ENGINEER'S HANDBOOK", McGraw Hill, New York, N.Y.

Bender, E. and Collins, A., "EFFECTS OF VIBRATION ON HUMAN PERFORMANCE: A LITERATURE REVIEW", NSRDC Report 1767, 15 February 1969.

Benham, R. B., "STATE OF THE ART REVIEW-SMALL GAS TURBINE ENGINE TECHNOLOGY", NAVAIR #NAPTC-PE-35, AD 781651, June 1974.

Beveridge, J. L., "THRUST DEDUCTION IN CONTRAROTATING PROPELLERS", NSRDC, Ship Performance Department, Report 4332, November 1974.

A theoretical method is presented for calculating the steady propulsive interaction (thrust deduction) force in contrarotating propellers. Contra-rotating propellers operating at off-design loading and spacing as well as the contribution of a rudder were investigated. The importance of the separate thrust deduction of the forward and aft propellers in analyzing the behavior of a CR Propeller set was shown. Numerical results are given for a MARAD high-speed containership. Some principal findings for the subject ship are: (1) good agreement between theory and experiment with regard to the thrust deduction of a centerline rudder, (2) at equal thrust the forward and aft propellers produced 73 percent and 27 percent of the total thrust deduction, respectively, and (3) the total thrust deduction is reduced by unbalancing the propelling thrust with smaller thrust carried on the forward propeller.

Beys, P. M., "SERIES 63, ROUND BOTTOM BOATS", Davidson Lab. SIT, Report No. 949, AD 412-788, April 1963.

Blount, D., "RESISTANCE AND PROPULSION CHARACTERISTICS OF A ROUND-BOTTOM BOAT (PARENT FORM OF TMB SERIES 63)", DTMB Report 2000, AD 614 565, March 1965.

This report gives the resistance and propulsion characteristics of the TMB Series 63 parent form. The data cover the effects of displacement, initial trim, and appendages. An example of the procedure to be followed in making a horsepower estimate using these data is included.

Blount, D. L. and Fox, D. L., "DESIGN CONSIDERATIONS FOR PROPELLERS IN A CAVITATING ENVIRONMENT", Hampton Roads Section, SNAME, September 29, 1976.

Cavitation adds a dimension to propeller operation that necessitates rational design practice to approach a good balance of craft requirements. This presentation discusses propeller characteristic format to reduce the computation time to make performance predictions and propeller selection for partially and fully cavitating conditions. In addition, maximum propeller thrust and torque loading limits are defined for four different blade section shapes including recommended design limits.

Blount, D. L. and Fox., D. L., "SMALL CRAFT POWER PREDICTION", SNAME, Marine Technology, Vol. 13, No. 1, January 1976.

A valid performance prediction technique for small craft is an invaluable tool not only for tne Naval Architect, but also for the operators and builders. This presentation describes the methodology for making speed-power prediction for hard chine craft of the types found in the offshore, military, and recreational applications. The distinct advantage of this method is that existing technical data have been organized into a logical approach, and areas of limited data have been overcome by the presentation of engineering factors based on model tests and full scale trials of specific hull forms. This speed-power prediction method accounts for hull proportions, loading, appendage configuration, propeller characteristics (including cavitation), and resistance augmentation due to rough water.

Blount, D. L. and Hankley, D. W., "FULL SCALE TRIALS AND ANALYSIS OF HIGH PERFORMANCE CRAFT DATA", SNAME, November 1976.

The proof of successful craft design processes is a direct result of proper analysis of full-scale craft test results and their correlation with prediction techniques. Based on the continuing need for full-scale correlation data, this paper offers data, the methods and conditions when obtained, and anlysis for a variety of high-performance, hard-chine craft. Comparisons are given for predicted and full-scale speed-power-rpm data for planing craft. The results indicate that correlation is significantly influenced by propeller cavitation and its uncertain effects on propulsive factors. Correlation factors are offered for both horsepower and rpm with indications that careful attention to underwater design details is very important for speeds above 25 knots. Full-scale seakeeping trials have been conducted recently, affording an opportunity to make comparisons with model motion and acceleration prediction. These data show that rigid-body motions and acceleration are generally overpredicted by model tests, but model data do not reflect the elastic qualities of the full-scale structure. Propeller induced hull pressures were measured and reported to provide limited mapping of the distribution and magnitude relative to propeller location. These data indicate varying conditions of propeller cavitation. The comprosing situation between strut strength and hydrodynamic fairing requires astute

judgement. A single-arm strut with an NACA 16 section was instrumented with strain gages, and data were recorded during straight runs and turns so that design conditions/criteria could be validated.

Boehe, R., "MODERN FAST PATROL BOATS", International Defense Review, Vol. 7, No. 6, pp 737-742, December 1974.

Brandau, J.H., "ASPECTS OF PERFORMANCE EVALUATION OF WATERJET PROPULSION SYSTEMS AND A CRITICAL REVIEW OF THE STATE OF THE ART", NSRDC Report 2550, October 1967; also AIAA Paper No. 67-360.

Brown, P.W., "AN EXPERIMENTAL AND THEORETICAL STUDY OF PLANING SURFACES WITH TRIM FLAPS", SIT, Davidson Lab Rept. R-1463, April 1971.

Brown, R.L., Robinson, T.H. "WHAT'S HAPPENING WITH MARINE ENVIRONMENTAL REGULATIONS", SNAME, Gulf Section, February 1975.

Buck, J., Kennel, C.G., Fuller, N.R., "PERFORMANCE CHARACTERISITCS OF HIGH PERFORMANCE AND ADVANCED MARINE (HIPAM)SURFACE VEHICLES", SNAME, Cheseapeake Section, October 1974.

Bureau of Ships, "WOOD: A MANUAL FOR ITS USE AS A SHIPBUILDING MATERIAL", Department of the Navy, NAVSHIPS 250-336, Four Volumes 1957 through 1962. Available from the Superintendent of Documents, Wahsington, D.C.

C

Caterpillar, "MARINE ENGINE APPLICATION AND INSTALLATION GUIDE", Caterpillar Tractor Co., Industrial Division, Peoria, Ill. 61602.

Chey, Y., "MODEL TESTS OF A SERIES OF SIX PATROL BOATS IN SMOOTH AND ROUGH WATER", SIT, Davidson Lab. Report 985, 1963.

Christopher, K. W., "EFFECT OF SHALLOW WATER ON THE HYDRODYNAMIC CHARACTERISTICS OF A FLAT-BOTTOM PLANING SURFACE", NACA TN 3642, 1956.

Clement, E. P., "A CRITICAL REVIEW OF SEVERAL REPORTS ON ROUND BOTTOM BOATS", DTMB, Tech. Note No. 40, 1963.

Clement, E. P., "A LIFTING SURFACE APPROACH TO PLANING BOAT DESIGN", DTMB Report 1902, 1964.

Clement, E. P., "ANALYZING THE STEPLESS PLANING BOAT", DTMB Report 1093, 1956.

Clement, E. P., "EFFECT OF LENGTH-BEAM RATIO ON THE PERFORMANCE OF A STEPPED PLANING BOAT WITH AN ADJUSTABLE STERN STABILIZER", DTMB Report 2552, 1967.

Clement, E.P., "EFFECTS OF LONGITUDINAL BOTTOM SPRAY STRIPS ON PLANING BOAT RESISTANCE", DTMB Report 1818, February 1964.

Experiments were made to determine the effects on planing boat resistance of several configurations of longitudinal bottom spray strips. It was found that such strips extending aft from the bow about 70 percent of the hull length decreased the resistance somewhat at high speed but increased the resistance at low speed. The performance was noticeably improved by sharpening the edges of the spray strips. An experiment was also made with bottom spray strips extending only forward of the high-speed stagnation line. This arrangement gave a 6-percent reduction in resistance at high speed with no increase in resistance at low speed.

Clement, E. P., "GRAPHS FOR DESIGNING CAMBERED PLANING SURFACES HAVING THE JOHNSON THREE-TERM CAMBERED SECTION, RECTANGULAR PLANFORM, AND ZERO DEADRISE", NSRDC Report No. 3147, 1969.

Clement, E. P., "GRAPHS FOR PREDICTING THE IDEAL HIGH-SPEED RESISTANCE OF PLANING CATAMARANS", DTMB Report 1573, 1961.

Clement, E. P., "HOW TO USE THE SNAME SMALL CRAFT DATA SHEETS FOR DESIGN AND FOR RESISTANCE PREDICTION", Technical and Research Bulletin No. 1-23, SNAME, May 1963.

Clement, E. P., "MERIT COMPARISONS OF THE SERIES 64 HIGH SPEED DISPLACEMENT HULL FORMS", DTMB Report 2199, 1965.

Clement, E. P., "PERFORMANCE LIMITS OF THE STEPLESS PLANING BOAT AND THE POTENTIALITIES OF THE STEPPED BOAT", Symposium on Small Craft Hydrodynamics, South East Section, SNAME, 1966.

Clement, E.P., "REDUCTION OF PLANING BOAT RESISTANCE BY DEFLECTION OF THE WHISKER SPRAY", DTMB Report 1929, November 1964.

Additional experimental verification is presented of the reduction of planing boat drag which can be achieved by using longitudinal strips forward of the stagnation line to deflect the whisker spray from the hull surface. In addition, graphs for determining the high-speed positions of the spray boundary and stagnation lines are given, to assist designers in locating spray deflectors on planing boats in the most effective positions.

Clement, E. P., "SCALE EFFECT ON THE DRAG OF A TYPICAL SET OF PLANING BOAT APPENDAGES", DTMB Report 1165.

Clement, E. P., "THE PLANING CHARACTERISTICS OF A 15-DEGREE DEADRISE SURFACE WITH CIRCULAR CAMBER", DTMB Report 2298, 1966.

Clement, E. P., and Blount, D. L., "RESISTANCE TESTS OF A SYSTEMATIC SERIES OF PLANING HULL FORMS", SNAME, 1963.

This paper presents the results of resistance tests of five planing boat models of different length-beam ratio. Each model was tested at a number of loads and LCG locations. The results are presented as curves of angle of attack and resistance-weight ratio versus Froude number. The resistance data have been corrected to boat weights of 10,000 and 100,000 lb. The measured values of wetted lengths, wetted surface, and rise of CG are also presented in tabular form. The conditions at which the models proposed at high speed were determined and a graph defining the stable and unstable regions is included. A method was ascertained of collapsing the high-speed resistance data from the tests of the series into single graph. A simplified prediction method was then developed which can be used to determine the high-speed resistance of planing hulls of a wide range of proportions, and of any gross weight from 1.000 to 100,000 lb.

Clement E. P. and Pope, J. D., "STEPLESS AND STEPPED PLANING HULLS - GRAPHS FOR PERFORMANCE PREDICTION AND DESIGN", DTMB Report 1490, 1961.

Clement, E.P., Springston, G.B. and Moore, W.L., "HYDRODYNAMIC DESIGN PROCEDURE FOR A DYNAPLANE BOAT", NSRDC Report No. 2871, June 1971.

Comstock, J. P., ed., "PRINCIPLES OF NAVAL ARCHITECTURE", SNAME, 1967.

Conolly, J. E., "ROLLING AND ITS STABILISATION BY ACTIVE FINS", RINA, March 1968.

Specification of the most suitable roll stabiliser for any particular ship requires the ability to predict motion under operational conditions with confidence during the design stage, and for this purpose, theory is developed and compared with the results of trial measurements on two ships together with supporting measurements on a model. The theory is shown to provide a satisfactory basis for the prediction of rolling motion and for distinguishing cases where a passive device is adequate to fulfill the operational requirements without the additional cost and complication of an active system. Simple tables are presented to facilitate such predictions.

It is shown that the performance of active stabilisers in the two trial ships could be represented theoretically with reasonable accuracy; this result justified the development of simple design techniques for specifying the required size and characteristics of active stabilisers to restrain rolling within selected limits.

Conolly, J. E., "STRENGTH OF PROPELLERS", RINA, December 1960.

Cox, G. G., and Lofft, R. F., "STATE-OF-THE ART FOR ROLL STABILIZERS", 14th International Towing Tank Conference, Report of Seakeeping Committee, Appendix 5, 1975.

The Crane Company, "FLOW OF FLUIDS", Technical Paper No. 410.

Cumming, R. A., "AN EXPERIMENTAL EVALUATION OF THREE METHODS FOR INCREASING THE LEADING EDGE THICKNESS OF SUPERCAVITATING PROPELLERS", DTMB Report 2197, August 1966.

D

Danahy, P. J., "ADEQUATE STRENGTH FOR SMALL HIGH SPEED VESSELS", SNAME, Marine Technology, January 1968.

A method for determination of minimum scantlings is presented. Several existing craft are included as examples.

D'Arcangelo, A. M., "A GUIDE TO SOUND SHIP STRUCTURES", Cornell Maritime Press, Cambridge, Md., 1969.

D'Arcangelo, A. M., ed., "SHIP DESIGN AND CONSTRUCTION:, SNAME, 1969.

Davidson, K. S. M., "WHAT PRICE SPEED? LONG RANGE TRENDS IN OVERSEAS TRANSPORTATION", SNAME, Chesapeake Section Oct. 14, 1954. Reprinted in SNAME Bulletin, Feb. 1955.

Detroit Diesel Allison, Division, General Motors, "MARINE ENGINE INFORMATION", seven section handbook providing installation data for all Detroit Diesel marine engines.

Demchik, R. P., "MARINE ENVIRONMENT EFFECTS ON FATIGUE CRACK PROPAGATION IN GRP LAMINATES FOR HULL CONSTRUCTION", MIT, MITSG #73-16, Nov. 73.

Denny, S. G., and Block, A. W., "ROLLING MOMENT CHARACTERISTICS OF A PLANING HULL WITH WEDGES", Ship Performance Department, Naval Ship Research and Development Center, Bethesda, Md. 20084, Report No. SPD-668-01, March 1976.

Captive model experiments were conducted to determine the roll moment producing capability of wedges appended to high speed planing hulls. The experiments determined the effects of wedge angle and wedge longitudinal position on the rolling moment produced for a range of speeds. Bare hull experiments were conducted at various roll angles to determine the magnitude of righting moment desired for the specific model hull used in the experiments.

The experimental data show that at high speeds and for the configurations evaluated, realistically sized 10° - 15° wedges (flaps), with wetted areas equal to 1% of hull wetted areas, can produce rolling moments of the same magnitude as those existing in a 10 degree craft roll.

Wedges are more effective in producing roll when the trailing edge of the wedge coincides with the hull transom than for wedge positions farther forward. However, the roll effectiveness of wedges at forward hull positions can be improved if the wedge trailing edge is ventilated.

Experimental data are also presented to show the effects of hull wedges on model drag, lift, sideforce, trimming moment, and yawing moment.

Douglas, B. E., and Kenchington, H. S., "MECHANICAL IMPEDANCE TECHNIQUES IN SMALL BOAT DESIGN", NSRDC, E/B Pend.

This paper is concerned with the use of mechanical impedance technology to isolate and diagnose the structural cause of airborne noise problems on small boats. A normal mode interpretation is given to analog mechanical impedance and structural radiation factor spectra in order to (1) identify hull and decking resonnances, (2) examine noise transmission path strengths and (3) differentiate between radiating structural modes and the normal acoustic modes of the room. These techniques were applied to solve an airborne noise problem on a 36-foot naval landing craft.

Du Cane, P.,"FAST PATROL BOATS" Symposium on Small Craft, The Royal Institute of Naval Architects, Southampton, September 1971.

The paper describes the development of the fast patrol boat in this country over the last 30 years, and illustrates the various classes which have seen service with the Royal Navy and other navies of the world.

The problems associated with the motor torpedo boats of the 1939-45 war are examined. The use of petrol engines, diesels and ultimately gas turbines as the means of propulsive power is reviewed, as is the related effect on the design of propellers. Hull form and machinery arrangements which have culminated in gas turbine driven craft, capable of speeds of 58 knots are described, and the author shows how the advent of the surface to surface missile has had a profound effect on the type of patrol boat which is evolving today.

Du Cane, P., "HIGH SPEED SMALL CRAFT", Fourth Edition, John De Graff, Inc., 34 Oak Avenue, Tuckahoe, N. Y. 11701, 1963.

Dyer, T. R., and Lundgaard, B., "NOISE CONTROL ON DIESEL TUGS", Marine Technology, SNAME, October 1973.

The paper briefly gives basic acoustic definitions and explains the fundamental concepts used in noise control. The mechanics of noise generation and the various methods used in noise suppression are explained. The silencing program employed on two sister tugs, Edith Lovejoy and Anne Carlander, is described in detail. The acoustic treatment of the tugs is not identical and the resulting noise level differences are discussed. Alternative acoustic approaches are described and evaluated. The paper is illustrated with graphs and tables of noise levels, and shows typical vessel arrangements and acoustic treatment details. A short bibilography is included.

E

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Ellis, W. E. and Alder, R., "PROPULSION EXPERIMENTS WITH A DEEP TUNNEL PLANING HULL", DTNSRDC Report SPD-717-01, August 1976.

Resistance and self-propulsion data are presented for Model 5048 fitted with tunnels equal in depth to basic propeller diameter. The relative merits of seven combinations of LCG position, propeller diameter and trim tabs are discussed. A forward LCG position offers the best combination of draft and shaft power. Comparisons are also made with the same hull without tunnels and with two sets of shallow tunnels. The 100 percent tunnel is inferior to both shallower tunnels in draft and power requirements, but it gives superior propeller protection for beaching operations. The 65% tunnel requires the least draft and gives good propeller protection, but it requires more power than the 40% tunnel.

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Falls, R. et. al., "A COMPARISON OF CONTRAROTATING PROPELLERS WITH OTHER PROPULSION SYSTEMS", SNAME, Chesapeake Section, Feb. 1971.

Femenia, "ECONOMIC COMPARISON OF VARIOUS MARINE POWER PLANTS", SNAME Transactions, 1973.

This paper is based on the results of two Maritime Administration sponsored studies. The paper compares the annual operating costs of various fossil fuel fired marine power plants. Included in the total operating costs are acquisition and financing costs, fuel oil costs, maintenance and repair costs, lubricating oil costs, crew-related expenses, and insurance costs. The first section of the paper presents the results of the study entitled "Power Plant Evaluation." The costs included in this study were obtained by compiling appropriate information from available reports and modifying the data to reflect plant differences and effects of inflation. Where sufficient data were unavailable, efforts were made to estimate the operating costs of the appropriate power plants. The costs included in this part of the paper are based on January 1971 prices. The second section of the paper presents the results of the study entitled "Combined Gas-Stream Turbine Marine Propulsion Cycles." This study was undertaken after the results of the power plant evaluation study showed that combined-cycle power plants might be competitive at high powers. In undertaking this study it was decided to develop eight combined gas-steam turbine power plants and to pursue an in-depth analysis of the operating costs of each plant. The costs included in this part of the paper are based on January 1972 prices.

Fox, U., "SEAMANLIKE SENSE IN POWERCRAFT", Published by Peter Davis, London, 1968.

Fridsma, G., "A SYSTEMATIC STUDY OF THE ROUGH WATER PERFORMANCE OF PLANING BOATS, PHASE II, IRREGULAR SEAS", SIT, DL Report 1495, Feb. 1971.

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Furio, A. J., Jr. and Gilbert, W. E., "ENERGY ABSORPTION AND IMPACT BEHAVIOR OF STIFFENED AND UNSTIFFEND ALUMINUM PANELS", NSRDC Report 44-9, Nov. 1974.

Good for estimating bottom damage due to impact on rocks under assumed conditions.

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Gabrielli, G. and Von Karman, Th., "WHAT PRICE SPEED? SPECIFIC POWER REQUIRED FOR PROPULSION OF VEHICLES, Mechanical Engineering, October 1950.

Gale, P. A., "MARGINS IN NAVAL SURFACE SHIP DESIGN", Naval Engineers Journal, April 1975.

Gawn, R. W. L., "EFFECT OF PITCH AND BLADE WIDTH ON PROPELLER PERFORMANCE", RINA, 1953.

Gawn, R. W. L., and Burrill, L. C., "EFFECT OF CAVITATION ON THE PERFORMANCE OF A SERIES OF 16-INCH MODEL PROPELLERS", Transactions RINA, Vol. 99, 1957.

Gelfer, "INORGANIC ZINC COATINGS ON UNDERWATER SURFACES", SNAME, San Diego Section, April 1974.

General Electric Co., "LM 2500 MARINE GAS TURBINE INSTALLATION DESIGN HANDBOOK".

Giannotti, Dr. J., and Fuller, N.R., Jr.,"SLAMMING OF HIGH PERFORMANCE MARINE VEHICLES", 11th Annual Symposium, Association of Senior Engineers.

The increasing demand for high performance marine vehicles has resulted in the need for new design concepts. High operational speeds and unconventional hull geometries make the design process differ from those used for conventional displacement mono-hull ships. One of the most critical areas encountered by the designer is the prediction of the magnitude and distribution of the impact pressure caused by slamming in clam water or in rough seas. This report reviews some of the existing slamming theories and suggests possible ways of making them applicable to the design of high performance marine vehicles. Areas where more research is needed are indicated and possible methods for design are recommended.

Gibbs and Cox, "MARINE DESIGN MANUAL FOR FIBERGLASS REINFORCED PLASTICS", McGraw-Hill Book Company, Inc., New York, N. Y. 1960.

Gibbs and Cox, "MARINE SURVEY MANUAL FOR FIBERGLASS REINFORCED PLASTIC", Owens-Corning Fiberglass Corp., 1962.

Goldberg, L. L., and Tucker, R. G., "CURRENT STATUS OF U. S. NAVY STABILITY AND BUOYANCY CRITERIA FOR ADVANCED MARINE VEHICLES", AIAA/SNAME Advanced Marine Vehicles Conference, San Diego, Calif., Feb. 1974, and Naval Engineers Journal, Oct. 1975.

Hullborne stability and byoyancy criteria (intact and damage) are presented for advanced marine vehicles such as hydrofoil craft, air cushion vehicles, surface effect ships, and low waterplane catamarans. Not covered is stability during flying or on-cushion modes.

The criteria attempt to recognize special operations and hazards associated with the unusual characteristics of these types. Examples are: the danger of large rip damage when flying at high speeds, the potential of large unsymmetrical flooding, and the lightweight structure resulting in less resistance to damage. The criteria presented herein are likely to change as more design and operational experience is acquired.

Graul, T., "FRESH WATER COOLING FOR MARINE ENGINES", Society of Small Craft Designers, Great Lakes Chapter, October 1964.

Graul, T., and Fry, E. D., "DESIGN AND CONSTRUCTION OF METAL PLANING BOATS", Proceedings of the Spring Meeting of SNAME, Montreal,Canada, 1967.

Gray, H. P., Allen, R. G., and Jones, R. R., "PREDICTION OF THREE-DIMENSIONAL PRESSURE DISTRIBUTIONS ON V-SHAPED PRISMATIC WEDGES DURING IMPACT OR PLANING", NSRDC Report 3795, Feb. 1972.

A computer program has been developed which calculates the water-pressure distribution on V-bottom prismatic wedges during impact and planing. The method of computation is based on proviously published semi-empirical procedures with several modifications that facilitate programming and result in close correlation to recently published experimental data.

The prismatic wedge may have any positive value of trim, deadrise angle, and wetted length. The pressure distribution for the entire hull or any given section of the hull may be calculated in specified increments by using the appropriate input data. Results obtained from the program are in reasonable agreement with certain published experimental planing data.

Gray, L. B., Blanton, W. J., and Granholm, L. E., "LEVEL FLOTATION, RESEARCH TO REGULATION", SNAME, Chesapeake Section, October 20, 1976.

Gregory, D. L., and Dobay, G. F., "THE PERFORMANCE OF HIGH-SPEED RUDDERS IN A CAVITATING ENVIRONMENT", SNAME, Spring Meeting, April 1973.

Force and moment coefficients for six high-speed craft rudders are presented. These experimental results indicate that the rudder section shape has little effect on the maximum lift coefficient, although the drag and rudder stock torque are influenced by the section shape. Lift, drag, and rudder stock torque are all significantly affected by variations in the cavitation number.

Details of the six rudder designs are presented and the relative merit of the designs is discussed. Recommendations for further investigation of high-performance craft rudders are included.

Hadler, J.G., "THE PREDICTION OF POWER PERFORMANCE ON PLANING CRAFT", SNAME Transactions, Vol. 74, 1974.

Much of the research effort on planing craft has been devoted to obtaining and predicting lift and drag of planing surfaces. Virtually no effort has been devoted to the hydrodynamics of the planing boat when propelled by marine propellers. This paper brings together the results of research on the marine propeller with those of the planing surface to develop a practical method for predicting the power performance of the planing craft when propelled by conventional marine propeller(s) driven by an inclined shaft. Developed in the paper are the various equations for determining the magnitude, location, and direction of the various hydrodynamic forces on the system. They are combined in the equations of equilibrium to establish the operating conditions and the power requirements of the boat. Predictions are then made for two different planing boat designs for correlation with model test results. Finally, the method is used to make a parametric study of the effect of angle of inclination upon planing boat performance. This study clearly shows that the drag of the appendages is secondary to the forces of the propellers and that in optimizing a planing boat design the whole hydrodynamic system must be considered.

Hadler, J.B., and Hubble, E.N., "PREDICTION OF THE POWER PERFORMANCE OF THE SERIES 62 PLANING HULL", SNAME Transactions, Vol. 79, 1971.

Results are presented of the first systematic study of the propulsion of planing craft, using propellers driven by inclined shafts with a rudder located behind each propeller. The study is focused on the resistance characteristics of three of the five models of DTMB Series 62. The propellers are derived from the extensive three-bladed Gawn-Burrill series, tested over a wide range of cavitation numbers. The performance predictions are based upon the method recently developed by Hadler. Single-, twin-, and quadruple-screw configurations have been studied for the Series 62 prototype hulls over a wide range of sizes and speeds. The results have been synthesized into design charts that provide (i) the optimum diameter-rpm for a given design displacement and speed, (ii) the value of the maximum propulsive coefficient, and (iii) the effect on propulsive efficiency of deviations from the optimum diameter. The charts may be easily used by the planing craft designer in making preliminary design and trade-off studies on propulsion systems of planing craft. Appendix 1 contains numerical examples of typical design studies, illustrating the use of the design charts.

Hall, D., "RUDDER DESIGN FOR PLANING CRAFT", The Planimeter, Oct. and Nov., 1962, Published by the Society of Small Craft Designers, c/o Carl J. Schnepf, Jr., 2656 Manker Street, Indianapolis, Indiana 46203.

Harbaugh, K., and Blount, D., "AN EXPERIMENTAL STUDY OF A HIGH PERFORMANCE TUNNEL HULL CRAFT", SNAME Spring Meeting, April 1973.

Model resistance and self propulsion data are presented from experiments on Model 5048 modified for shallow and deep tunnels and with propellers of two different diameters. Comparisons are made with data previously obtained for the same model without tunnels, and the tunnel configurations are evaluated by means of an efficiency factor. The deep tunnelled hull in combination with propellers of large diameter and the smallest permissible tip clearance compares performancewise to the hull with no tunnels. A format and sufficient dimensionless coefficients are provided for horsepower estimates for alternate hull designs. Because the navigational draft requirements for the tunnel hull are much less than those without tunnels, the tunnel hull is considered to be highly desirable.

Harrington, R.L., Editor, "MARINE ENGINEERING", SNAME, 1971.

Hecker, R., "EXPERIMENTAL PERFORMANCE OF A PARTIALLY SUBMERGED PROPELLER IN INCLINED FLOW", SNAME Spring Meeting, April 1973.

Hecker, R., and Crown, D.E., "VENTILATED PROPELLER PERFORMANCE", NSRDC Report 3353, June 1971.

Hecker, R., and McDonald, Neil A., "THE EFFECT OF AXIAL SPACING AND DIAMETER ON THE POWERING PERFORMANCE OF COUNTERROTATING PROPELLERS", DTMB, Report 1342, Feb. 1960.

An investigation of counterrotating (CR) propellers was conducted at the David Taylor Model Basin. For this investigation a series of counterrotating propellers was designed and tested in open water. Part of this series was used to investigate the effects of axial spacing on efficiency while another part was used to study the effect of the forward propeller diameter on efficiency. Two methods, one theoretical and one empirical, were used to predict the optimum forward diameter.

The results show that axial spacing has a negligible effect on efficiency as long as the propellers are operating at their design spacing. The effect of forward propeller diameter on efficiency is shown to be

essentially the same as for single propellers. The results further indicate that either of two methods used to determine the optimum forward diameter is adequate. Due to limitations imposed by the test equipment the propellers were run at Reynolds numbers lower than usually considered acceptable.The experimental results, however, compare well with theory.

Hecker, R., Peck, J.G., & McDonald, N., "EXPERIMENTAL PERFORMANCE OF TMB SUPERCAVITATING PROPELLERS", DTMB Report No. 1432, Jan. 1964.

Hecker, R., Shields, C., & McDonald, N., "EXPERIMENTAL PERFORMANCE OF CONTROLLABLE PITCH SUPERCAVITATING PROPELLERS", NSRDC Report No. 1636, Aug. 1967.

Heller, S.R., Jr., and Clark, Dennis J., "THE OUTLOOK FOR LIGHTER STRUCTURES IN HIGH PERFORMANCE MARINE VEHICLES", SNAME, Marine Technology, Oct. 1974.

Structural weights of existing high performance marine vehicles, principally hydrofoil craft, are examined to determine the design or geometric parameters that have significant effect. For total structural weight, vehicle density and structural density are shown to be governing. Similarly, the governing parameters for individual weight groups are identified. These governing parameters and the loads which determine scantlings, where known, are compared to develop measures of efficient use of structural material. These figures of merit are applied to a number of high performance marine vehicles and projections of what might be attainable in the future are made.

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Henry, Charles J., "CALM WATER EQUILIBRIUM, DIRECTIONAL STABILITY AND STEADY TURNING CONDITIONS FOR RECREATIONAL PLANING CRAFT". SIT, DL Report 1851, October 1975.

Henshall, S.H., "MEDIUM & HIGH SPEED DIESEL ENGINES FOR MARINE USE", Institute of Marine Engineers, 1972.

Hind, J.A., "STABILITY AND TRIM OF FISHING VESSELS", Fishing News (Books) Ltd., 110 Fleet Street, London, E.C.4., England.

Hires, R.I., "RECREATIONAL CRAFT PERFORMANCE STUDY--PITCH AND HEAVE RESPONSE OF THREE PLANING CRAFT AT ZERO SPEED IN FOLLOWING SEAS", Stevens Institute of Technology, Davidson Laboratory Report 1850, September 1975.

Hobbs, R.W., "HYDRODYNAMIC SURFACE SELECTION FOR OPTIMUM PERFORMANCE IN PLANING BOAT POWER SELECTION", R.W. Hobbs Report 7006, Coral Gables, Florida, October 1972.

Hockberger, W.A., "SHIP DESIGN MARGINS - ISSUES AND IMPACTS", ASNE, Naval Engineers Journal, April 1976.

Hockberger, W.A., "THE IMPACT OF SHIP DESIGN MARGINS", NAVSEC Concept Design Division, 6112-082-75, AD-A015 638/OWO, 1 September 1975.

Hoerner, S.R., "FLUID DYNAMIC DRAG", 148 Busteed Drive, Midland Park, N.J.

Holtyn, C.H., "ALUMABILITY", SNAME Spring Meeting, April 1973.

Holtyn, C.H., "STATUS OF ALUMINUM SMALL BOAT STANDARDS AND RECOMMENDED PRACTICES", Southeast Section, SNAME, September 1967.

Hubble, N., "CORRELATION OF RESISTANCE TEST RESULTS FROM FIXED- AND FREE-TO-TRIM METHODS FOR A DYNAMIC-LIFT (MODEL 4667)", NSRDC, Ship Performance Department Report 3544, April 1972.

Customary methods are discussed for determining the resistance characteristics in smooth water of hulls of planing craft. Results are presented and compared for a hull, with possible application to either type of craft, which has been tested by both the fixed-trim method, generally used for hydrofoil craft, and the free-to-trim method, generally used for planing craft. Recommendations are made for conducting future resistance tests of dynamic-lift craft, i.e., both planing and hydrofoil hulls, in the fixed trim mode as well as for converting the data to the form of free-to-trim test data to facilitate general design studies for both types of craft.

Hubble, N., "RESISTANCE OF HARD-CHINE, STEPLESS PLANING CRAFT WITH SYSTEMATIC VARIATION OF HULL FORM, LONGITUDINAL CENTER OF GRAVITY, AND LOADING", NSRDC Report 4307, April 1974.

J

Jacob, M., and Hawkins, G.A., "ELEMENTS OF HEAT TRANSFER", John Wiley and Sons, 1957.

Jones, R.R., and Allen, R.G., "A SEMI-EMPIRICAL COMPUTERIZED METHOD FOR PREDICTING THREE DIMENSIONAL HULL/WATER IMPACT PRESSURE DISTRIBUTIONS AND FORCES ON HIGH PERFORMANCE HULLS", NSRDC Report 4005, December 1972.

This report describes the development and usage of a semi-empirical, quasi-static computerized method for calculating instantaneous three- dimensional water pressure distributions on high-speed marine vehicles. The method can simulate either planing or hull-wave impacts in three degrees of motion-pitch, heave, and surge. The analysis technique requires hull offsets, trochoidal wave parameters, and such initial condition information as the hull position, the vertical and horizontal velocity components, and the pitch rate. The method can be used to obtain results of varying complexity, including a description of normal pressures for all or selected portions of the hull, a normalized pressure versus impact area relationship, and horizontal and vertical impact forces. The results of its application to the analysis of the hull-wave impact of two model hull configurations are presented although the computer program developed for the method is not documented in this report.

This program, called IPPRES, is a large and complicated program. Because of its expense it should be used only in cases of unusual hull shapes where accurate predictions are required. For conventional planing hulls the Heller-Jasper theory is a reasonably accurate tool for generating load criteria for structural design and remains, with minor modification, the most useful and dependable method available for preliminary design.

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Karanzalis, "HEATING, VENTILATION, AIR CONDITIONING AND THE ENVIRONMENT", SNAME, Philadelphia Section, April 1975.

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Kimon, P.M., "THE PLANING CHARACTERISTICS OF AN INVERTED-V PRISMATIC SURFACE WITH MINUS 10 DEGREES DEADRISE", DTMB Report 1076, 1957.

Kinney, F.S., "SKENE'S ELEMENTS OF YACHT DESIGN", Dodd, Mead & Company, New York, N.Y., 1973.

Klingel, G.C., "BOATBUILDING WITH STEEL", including Colvin, T., "BOATBUILDING WITH ALUMINUM", International Marine Publishing Co., Camden, Maine , 1973.

Koelbel, J.G., Jr., "PROCEDURES MANUAL - DYNAMIC STABILITY ANALYSIS OF U.S. NAVY SMALL CRAFT", Combatant Craft Engineering, Naval Ship Engineering Center, Norfolk Division, Norfolk, Va. Report No. 23094-1, January 1977.

Koelbel, J.G., Jr., "THE DETAIL DESIGN OF PLANING HULL FORMS", paper presented at the Synposium on Small Craft Hydrodynamics, Southeast Section of SNAME, Miami, 27 May 1966.

Koelbel, J.G., Jr., "RESISTANCE, PROPULSION AND SEAKEEPING", University Of Michigan, Dept. of Naval Architecture, Report 120, October 1971.

Koelbel, J.G.,Jr., "PERFORMANCE PREDICTION", in University of Michigan, "SMALL CRAFT ENGINEERING", Report 120.

Koelbel, J.G., Jr., "BIBLIOGRAPHY OF POWER BOAT DESIGN", Report No. 120-1, Available from Society of Naval Architects and Marine Engineers, 1 World Trade Center, New York, N.Y. 10048.

Koelbel, J.G., Jr., "GUIDE TO POWER BOAT DESIGN", Report No. 120-2, Available from Society of Naval Architects and Marine Engineers, 1 World Trade Center, New York, N.Y. 10048.

Kress, R.F., "HIGH-SPEED PROPELLER DESIGN", SNAME, Spring Meeting, April 1973.

Kress, R., and Lorenz, E.L., "MARINE PROPELLER SELECTION", Paper No. 700094, Automotive Engineering Congress, Detroit, Michigan, SAE.

Kroeger, N.B., Jr., and Cummings, D.F., "SUBCAVITATING PROPELLER DESIGN FOR MAXIMUM PROPELLER EFFICIENCY OR MINIMUM FUEL USE", Marine Technology SNAME, April 1974.

An optimization procedure is described for the design of a subcavitating propeller for given service conditions. Strength and cavitation criteria are included. Diameter, rpm, chord lengths, pitch distribution, camber distribution and thickness distribution are developed for the optimum performance. The optimum propeller is defined as that using the minimum power at a given ship speed. Characteristics of the propeller at other than design conditions may be derived.

Kruppa, C., "TESTING OF PARTIALLY SUBMERGED PROPELLERS", 13th ITTC, Cavitation Committee Report, Appendix V.

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Kruse, D.K., "ANALYSIS OF A METHOD FOR OPTIMUM DESIGN OF WATERJET PROPULSION SYSTEMS", MIT, June 1973.

Kruse, "WATERJET PROPULSION - AN OPTIMIZATION PROCEDURE", SNAME, Philadelphia Section, January 1974.

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Lev, F.M., and Nappi, N.S., "PROPERTIES OF COMBINED ALUMINUM BEAM AND PLATE", NSRDC Report 4336, March 1974.

Tabulation of dimensional data, section modulus and moment of inertia of beam-plate combinations for all standard SNAME Tee Sections plus built-up Tees to 27 inches in depth.

Lewis, D.P., and Snuggs, J.F., "AIRBORNE NOISE CONTROL AS APPLIED TO HIGH PERFORMANCE CRAFT", 11th Annual Symposium of the Association of Senior Engineers, February 1974.

This paper familiarizes the reader with the basic concepts of airborne noise control and demonstrates their application during ship design and construction to produce airborne noise acceptable ships. In view of the special size and weight constraints which exist for high performance craft, major emphasis is placed on the efficiency of the alternative noise control methods. A simplified noise prediction technique for use by non-acoustically trained engineers is presented. Although not sufficiently detailed for a thorough noise analysis, the method provided can be useful in conducting trade-off analyses, and in verifying the results of more detailed efforts. The limitations of the theoretical noise studies, including the effects of airborne and structural flanking paths, are discussed with emphasis on the special case of high performance craft.

Lincoln Electric, "PROCEDURES HANDBOOK OF ARC WELDING", The Lincoln Electric Company, 22801 St. Claire Avenue, Cleveland, Ohio 44117.

Lindenmuth, W.T., and Barr, R.A., "STUDY OF THE PERFORMANCE OF A PARTIALLY SUBMERGED PROPELLER", Hydronautics, Inc., Technical Report 760-1, July 1967.

Lippisch, A.M., and Colton, R.E., "STEPPED PLANING BOATS, SOME FULL-SCALE TEST RESULTS", SNAME, T AND R Report R-9, May 1970.

Lippmann, G.J., "SMALL CRAFT STANDARDS", SNAME Spring Meeting, April 1973.

Lloyds, "PROVISIONAL RULES FOR THE CONSTRUCTION OF REINFORCED PLASTIC YACHTS".

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Lord, L., "NAVAL ARCHITECTURE OF PLANING HULLS", Cornell Maritime Press, Cambridge, Maryland, 1954.

Lueders, D., "MODEL TESTS OF TWO PLANING FORMS AND A ROUNDED BOTTOM FORM IN AN IRREGULAR SEA", SIT, DL Report 478-H-01, June 1972.

Lundgaard, M., "PGM 84 CLASS ALUMINUM GUN BOAT MACHINERY AND CONTROLS" SNAME/AIAA Symposium, May 1967.

Lundgaard, "THE RELATIONSHIP BETWEEN MACHINERY VIBRATION LEVELS AND MACHINERY DETERIORATION AND FAILURES", Marine Technology SNAME, January 1973.

The paper proposes the use of periodic vibration monitoring as a diagnostic maintenance tool. For a small initial investment, the monitoring program will provide in most cases an early warning of impending equipment failure. Vibratory frequency is used to determine the nature of a malfunction, while the amplitude history indicates the seriousness of the problem. This information is useful in determining when to overhaul a machinery item and how extensive the overhaul should be.

Lundgaard, B., and Grant, "NEW METHODS OF VIBRATION AND STRESS MEASUREMENTS IN ROTATING MACHINERY", SNAME, Pacific Northwest Section, October 1974.

Lutowski, R.N., "A COMPUTER PROGRAM FOR VARIOUS ASPECTS OF PLANING CRAFT", Masters Thesis, Stevens Institute of Technology, 1973.

A computerized procedure for the calculation of shaft horsepower of planing surfaces is presented. Taken into account are appendage, wind, and propeller-induced forces in addition to the forces commonly used to evaluate effective horsepower. To this central program are added subroutines for the estimation of porpoising stability and rough water performance. From a computer software standpoint, the program has the virtues of high execution speed and modest core requirement, making it suitable for design trade-off studies. It is intended that this program will not merely supplement, but will replace, existing EHP prediction programs for most design applications. Thus, it is hoped that a useful tool has been added to the computer-aided design inventory of the small boat naval architect.

M

Marshall, "SHOP APPROACH TO FABRICATION OF ALUMINUM BOATS", SNAME, Pacific Northwest Section, January 1974.

Martin, M., "THEORETICAL PREDICTION OF MOTIONS OF HIGH SPEED PLANING BOATS IN WAVES", DTNSRDC Report 76-0069, April 1976.

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Marwood, W.J., and Bailey, D., "DESIGN DATA FOR HIGH SPEED DISPLACEMENT HULLS OF ROUND BILGE FORM", National Physical Laboratory, Ship Division, Teddington, England. Report No. 99, February 1969.

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McAnnally, W.J., "SMALL TURBINE ENGINE TECHNOLOGY", Pratt & Whitney Aircraft, 1974.

McCoy, "GAS TURBINE PROPULSION FOR HIGH-SPEED SMALL CRAFT", SNAME Los Angeles Section, January 1968.

McGown, S.C., "THE SEAWORTHINESS PROBLEM IN HIGH SPEED SMALL CRAFT", SNAME New York Metropolitan Section, January 24, 1961.

One of the most challenging areas in small craft design today is imp vement of seaworthiness at high speed. Types of hull forms adapted for the optimum combination of high speed and good rough water performance at high speeds are discussed. The merits and limitations of the "round bottom form" and the "hard chine form" are compared. It is contended that for speed/lenght ratios up to the range of 3.5 the "slender" round bilged form is generally superior providing the necessary speed potential with good seaworthiness. For speed/length ratios in excess of 4.o the hard chine boat is favored for its lower resistance characteristics at these high speeds. The limited seaworthiness of the hard chine boats at high speed in rough water is discussed and an analysis is made of the features of these craft which contribute to good and poor rough water performance. The lack of systematic comparative test data, either model or full scale, to clarify the effect of various features of hull form on behavior prohibits concrete conclusions, however a critique is made of a number of high speed designs providing a background for further scientific investigation.

Meese, "SOME CONSIDERATIONS IN POWER CRUISER DESIGN", SNAME Spring Meeting, 1973.

Mercier, J. A., "IMPACT LOADS ON WARPED PLANING SURFACES LANDING ON SMOOTH AND ROUGH WATER", Davidson Laboratory, Stevens Institute of Technology, Report 1514, March 1971.

Mercier, J. A. and Savitsky, D., "RESISTANCE OF TRANSOM-STERN CRAFT IN THE PRE-PLANING REGIME", Stevens Institute of Technology, Davidson Laboratory Report 1667, June 1973.

An analytical procedure is presented for predicting the resistance of transom-stern hulls in the non-planing range -- specifically for volume Froude numbers less than 2.0. The predictive technique is established by a regression analysis of the smooth-water resistance data of seven transom-stern hull series which included 118 separate hull forms.

The statistically-based correlation equation is a function of slenderness ratio, beam loading, entrance angle, ratio of transom area to maximum section area and volume Froude number. This equation can be used to estimate the low Froude number resistance of planing hull froms in the early stages of design.

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Bailey, D., "PERFORMANCE PREDICTION - FAST CRAFT"

Howlett, I., "CONSIDERATIONS RELATING TO THE PERFORMANCE OF LARGE SAILING VESSELS"

Sharples, A.K., "SMALL PATROL CRAFT"

Stevens, M.J., "SOME ASPECTS OF THE PERFORMANCE PREDICTION OF OIL RIG SUPPLY VESSELS".

Millward, A., "THE EFFECT OF WEDGES ON THE PERFORMANCE CHARACTERISTICS OF TWO PLANING HULLS", SNAME, Journal of Ship Research, December 1976.

An investigation has been made into the effect of adding wedges or trim tabs to two models of the DTMB Series 62 planing hulls over a range of longitudinal center of gravity positions and displacements to determine the optimum wedge configuration and the range of effectiveness of a wedge.

Measurements were also made to determine whether a wedge had an effect on the dynamic lift on the hull and hence whether there was a change in resistance other than that resulting from control of the trim angle.

Momany, N., "DESIGN GUIDELINES FOR PRESSURE RELIEF-FLAME DEFLECTORS FOR INBOARD/OUTDRIVE RECREATIONAL BOATS", Wyle Labs., Huntsville, Alabama, MSR-75-25, USCG-D-131-75, AD-A014 093/0WO, July 1975.

Moody, C. G., "HYDRODYNAMIC CHARACTERISTICS OF A CONTROL SURFACE", DTNSRDC, SPD-640-01, AD-A015 962/4WO, September 1975.

Moore, W.L., "CAMBERED PLANING SURFACES FOR STEPPED HULLS - SOME THEORETICAL AND EXPERIMENTAL RESULTS", DTMB Report 2387, 1976.

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NAVSHIPS, "WOOD, A MANUAL FOR ITS USE AS A SHIPBUILDING MATERIAL", Vol. I., II, III, and IV, 250-336, Supt. of Documents, Government Printing Office, Washington, D C., 1957-1962.

NAVSHIPS, "WEIGHT CLASSIFICATION FOR BOATS OF THE U.S. NAVY", 0929-000-4010.

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Newton, R.N. & Rader, H.D., "PERFORMANCE DATA OF PROPELLERS FOR HIGH SPEED CRAFT", Transactions RINA Vol. 103, 1961.

NFPA, "FIRE PROTECTION STANDARDS FOR MOTOR CRAFT, NFPA 302", National Fire Protection Association, 60 Batterymarch Street, Boston, Mass. 02110.

Noonan,"AN ASSESSMENT OF CURRENT SHIPBOARD VIBRATION TECHNOLOGY", SNAME Symposium, October 1974.

Norgaard, "ALUMINUM CREW BOATS", SNAME, Northern California Section, October 1967.

Numata E., and Lewis, E.V., "AN EXPERIMENTAL STUDY OF THE EFFECT OF EXTREME VARIATIONS IN PROPORTIONS AND FORM ON SHIP MODEL BEHAVIOR IN WAVES", Stevens Institute of Technology, Davidson Laboratory Report No. 643, 1957.

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O'Brien, T.P., "THE DESIGN OF MARINE SCREW PROPELLERS", Hutchinson Scientific and Technical, London, 1962.

Owens-Corning - "BOATBUILDER'S ANSWER BOOK", A collection of technical publications.

Payne Inc., "A NOTE ON ROLL STABILIZATION AND CREW EFFICIENCY", April 1976.

Peck, J.G., "TUNNEL HULL CAVITATION AND PROPELLER INDUCED PRESSURE INVESTIGATION", NSRDC, SPD-507-01, November 1974.

Cavitation performance of two propellers at different hull clearance-to-diameter ratios in a tunnel hull model are presented, as well as the propeller-induced pressures measured in the tunnel wall. Cavitation performance of the two propellers in uniform flow is also included. The propellers operating in the tunnel hull were found to be more efficient than in uniform flow. Predominant features of the induced pressure measurements were the blade-frequency harmonics. There was no evidence of flow separation on the tunnel hull model at simulated ship speeds of 45 knots.

Peck, J.G., and Fisher, B.L., "CAVITATION PERFORMANCE OF PROPELLERS WITH AND WITHOUT CUPPING", DTNSRDC Report SPD-725-C1, September 1976.

Peck, J.G., and Moore, D.H., "PERFORMANCE CHARACTERISTICS OF FOUR INCLINED SHAFT PROPELLERS", SNAME, Spring Meeting, April 1973.

Most small naval craft utilize commercially available propellers on inclined shafts as thrusters. Information on the forces generated by inclined shaft propellers is scarce. In order to help the designer of small craft, an experimental program was undertaken to evaluate commercially available propeller performance when inclined to the oncoming flow. A series of four, 4-bladed, commercial propellers with pitch ratios, P/D, of 0.8, 1.0, 1.2, and 1.4 were characterized over a range of shaft angles, cavitation numbers and advance coefficients. Besides the usual shaftline thrust and torque, horizontal and vertical side forces were also measured. The results of these experiments support the previous assumption that a propeller on an inclined shaft may produce more forward thrust than the same propeller on a horizontal shaft. This paper contains propeller characteristic curves and lift- and side-force data which are directly applicable in the design of high-performance small craft.

Phillips-Birt, D., "NAVAL ARCHITECTURE OF SMALL CRAFT", The Philosophical Library, 15 East 40th Street, New York, N.Y. 10016, 1957.

Pike, J.W., "WEIGHT CONTROL ON A HIGH PERFORMANCE CRAFT", 11th Annual Symposium of the Association of Senior Engineers, March 1974.

This paper describes the weight control program, and results, on a new high speed fast patrol boat. The Coastal Patrol and Interdiction Craft, called CPIC, is a 100 foot, high performance combatant craft.

Weight (and displacement) of combatant craft is critical to successful performance. The CPIC was designed to carry a specific weapon system and has a specific mission profile. Growth in displacement would seriously impact on the engine power required and impact on the size and cost of the craft. Differences in the designers and builders weight estimates were sufficient to question the adequacy of the main propulsion system with regard to speed, endurance and the attendant engineering review became the most significant controls over the contractor.

The weight control efforts and results are described with a general over-view of the project. No contract requirements existed for stringent weight control performance. The methods by which control was developed on the existing contract are discussed, and observations provided for consideration in developing improved control methods.

Powell, "ELECTRICAL INSTALLATION ON FISHING VESSELS", SNAME, Canadian Maritime Section, March 1969.

Pratt & Whitney Co., "PRATT & WHITNEY FT4 GAS TURBINE INSTALLATION HANDBOOK".

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Ravenscroft, L.T., et. al., "PRECOMMENDED VEHICLE CONCEPTS FOR WATERJET PROPELLED HIGH PERFORMANCE VEHICLES", NSRDC TN-SPD-572-01, AD# A004621, December 1974.

Rawat, P., "A SYSTEMS APPROACH TO HULL STRUCTURE DESIGN", Naval Engineers Journal, October 1970, Vol. 82, No. 5.

Reed, F.E., "ACCEPTABLE LEVELS OF VIBRATION ON SHIPS", SNAME, Marine Technology, April 1973.

The Draft International Standard ISO/DIS 2631 "Guide for the Evaluation of Human Exposure to Whole-Body Vibration" provides an excellent base for setting acceptable levels of vibration on ships. A standard for evaluating vibration levels has been needed for some time and the new standard not only provides a sound foundation for evaluating vibration, but also permits the vibration levels to be rated numerically as percentages of the established standard of fatigue-decreased proficiency. The standard is related to frequency, direction of motion, and the time exposure at the different locations in the ship. "Safe exposure limits" and "reduced comfort limits" are defined in terms of percentages of this same fatigue-decreased proficiency level.

NOTE: Since the preparation of this paper, the Draft International Standard has been adopted as a standard not only of the International Standards Organization but also of the American National Standards Institute.

Roark, R.J., "FORMULAS FOR STRESS AND STRAIN", McGraw-Hill Book Co., Inc.

Rubis, C.J., "ACCELERATION AND STEADY STATE PROPULSION DYNAMICS OF A GAS TURBINE SHIP WITH CONTROLLABLE-PITCH PROPELLER", SNAME, 1972.

Rukin, J.B., "RECOMMENDED GUIDE FOR ALUMINUM CREWBOATS AND YACHTS", Reynolds Metals Co., P.O. Box 2346, Richmond, Virginia 23218.

Sarchin, T.H. and Goldberg, L.L., "STABILITY AND BUOYANCY CRITERIA FOR U.S. NAVAL SURFACE SHIPS", SNAME, Transactions, 1962.

Methods and criteria used in assessing stability and buoyancy for naval ships. Methods could be applied and criteria adjusted for small craft.

Saunders, H. E., "HYDRODYNAMICS IN SHIP DESIGN", Three Volumes, SNAME, 1957 and 1965.

Sauthulis, C., Bowman, J. and Chadwick, T., "LEVEL FLOTATION STANDARDS ANALYSIS RESEARCH AND DEVELOPMENT REPORT", Wyle Labs., Huntsville, Alabama. MSR-74-16, USCG-D-112-75, AD-A014 645/6WO, May 1975.

Savitsky, D., "SMALL CRAFT BEHAVIOR IN A SEAWAY", Contained in University of Michigan, Department of Naval Architecture Report 120, October 1971.

Savitsky, D., "ON THE SEAKEEPING OF PLANING HULLS", Marine Technology, April 1968.

An analysis is made of available data on the seakeeping behavior of planing hulls in order to define and categorize those hydrodynamic problems associated with various speeds of operation in a seaway. It is found that seakeeping behavior at speed-length ratios less than 2.50 is distinctly different than the behavior at larger speed-length ratios. Analysis is made of the rough-water accelerations for both speed regions and-heave motions; and the impact accelerations for both speed regions in head and following seas. The effect of hull trim and hull section form on these rough-water hydrodynamic characteristics is discussed.

Savitsky, D., "HYDRODYNAMIC DESIGN OF PLANING HULLS", SNAME, Marine Technology, Volume 1, Number 1, October 1964.

The elemental hydrodynamic characteristics of prismatic planing surfaces are discussed and empirical planing equations are given which describe the lift, drag, wetted area, center of pressure, and porpoising stability limits of planing surfaces as a function of speed, trim angle deadrise angle, and loading. These results are combined to formulate

simple computational procedures to predict the horsepower requirements, running trim, draft, and porpoising stability of prismatic planing hulls. Illustrative examples are included to demonstrate the application of the computational procedures.

Savitsky, D. and Breslin, J., "ON THE MAIN SPRAY GENERATED BY PLANING SURFACES", SMF Fund Paper No. FF-18, IAS, January 1958.

Savitsky, D. and Brown, P. W., "PROCEDURES FOR HYDRODYNAMIC EVALUATION OF PLANING HULLS IN SMOOTH AND ROUGH WATER", SNAME, MARINE Technology, October 1976.

Recent Davidson Laboratory basic studies of planing hull hydrodynamics have produced a wealth of technology which is not generally available to the small boat design profession. Included are studies related to the pre-planing resistance of transom stern hulls; the effectiveness of trim control flaps; the effect of bottom warp on planing efficiency; the influence of re-entrant transom forms; and the seakeeping of planing hulls.

The present paper consolidates these results in a form suitable for design purposes and illustrates their application in predicting planing performance in smooth and rough water.

Sawyer, J.W., Editor, "SAWYER'S GAS TURBINE CATALOG", Gas Turbine Publications Inc., Stamford, Conn., 1975.

Scherer, J. O. and Bohn, J.D., "PARTIALLY SUBMERGED SUPERCAVITATING PROPELLERS-PARAMETRIC ANALYSIS AND DESIGN OF A FAMILY OF NINE MODEL PROPELLERS", Hydronautics Inc., Techn. Report 7307-1, December 1973.

Schiff, M.I., "CASE HISTORIES OF THE SILENCING OF MARINE GAS TURBINES", SNAME, New York Metropolitan Section, December 1973.

Schomber, G.&G., "TESTING RESEARCH FOR THE DETERMINATION OF STRESSES IN SMALL CRAFT HULLS", SNAME, S.E. Section, September 1967.

Schrader, A.R., "DIESEL ENGINE DESIGN STUDY", NSRDC #1-40, May 1972.

Scott, R. S., "FIBERGLASS BOAT DESIGN AND CONSTRUCTION", International Marine Publishing Co., 21 Elm Street, Camden, Me.

This book contains material similar to the University of Michigan Report 121.

Scott, R.S., "FIBERGLASS REINFORCED PLASTIC", Part of "SMALL CRAFT ENGINEERING STRUCTURE", University of Michigan, Department of Naval Architecture Report 121, Ocotober 1971.

Sejd, J.J., "MARGINAL COST - A TOOL IN DESIGNING TO COST", 11th Annual Symposium of the Association of Senior Engineers, March 1974.

The concept of marginal cost, i.e., the cost of one additional unit at some specified level, can be applied to Naval ship design with considerable benefit. Weight, space, electric power and manning are commodities by which most subsystems and equipments influence ship size and cost. By developing marginal cost factors about a base-line design for these commodities, it is possible to estimate the shipboard cost influence of a wide variety of subsystems without the necessity of specific design studies. Answers can be provided in minutes rather than days or weeks. Additionally, marginal cost factors provide the naval architect with a new insight into his design, a guide for trading between commodities, and a means of quickly assessing his capability to reach a target cost.

This paper shows the development of marginal cost factors for a Destroyer Escort of about 3,500 tons full load displacement, Potential problem areas are discussed and an example of marginal cost application is offered.

Shields, C.E. and Foster, J.J., "ACTIVE FIN ROLL STABILIZATION EFFECTIVENESS ON A 65' TORPEDO RETRIEVER BOAT (TRB)", NAVSECNORDIV Report 6660-20, October 1975.

Shuford, C.L. Jr., "A THEORETICAL AND EXPERIMENTAL STUDY OF PLANING SURFACES INCLUDING EFFECTS OF CROSS SECTION AND PLAN FORM", NACA Report 1355, 1957.

Silverleaf, A. and Cook, F.G.R., "A COMPARISON OF SOME FEATURES OF HIGH SPEED MARINE CRAFT", paper read at the Royal Institute of Naval Architects, London, England, March 1969.

Silvia, P. A., "SMALL CRAFT ENGINEERING STRUCTURES", University of Michigan, Department of Naval Architecture, Report 121, October 1971.

Simon, L.E., "ENGINEERS MANUAL OF STATISTICAL METHODS", John Wiley and Sons.

Smith, "BUCKLING PROBLEMS IN THE DESIGN OF FIBERGLASS-REINFORCED PLASTIC SHIPS", SNAME, Journal of Ship Research, September 1972.

SNAME, "SMALL CRAFT DATA SHEETS".

SNAME,"PRINCIPLES OF NAVAL ARCHITECTURE", J.P. Comstock, ed., by a group of authorities, 1967.

SNAME, "ALUMINUM FIRE PROTECTION GUIDELINES", T&R Bulletin 2-21, July 1974.

SNAME, "COATING SYSTEMS GUIDE FOR HULL, DECK AND SUPERSTRUCTURE", T&R Bulletin No. 4-10, 1973.

SNAME, "GUIDE FOR THE SELECTION OF WROUGHT ALUMINUM PLATE AND SHAPES FOR SHIP STRUCTURES", Task Group HS-6-1, T&R No. 2-15, 1968.

Solberg, Cromer and Spaulding, "THERMAL ENGINEERING", John Wiley & Sons, 1960.

Southhampton, University of, "PROCEEDINGS OF THE SYMPOSIUM ON SMALL CRAFT", September 1971. Papers were presented on:

1. Offshore Racing Powerboat Design and Development by W. H. Maloney
2. Marine Jet Units by A. C. Walker
3. Pilot Launches-Design and operation by A. K. Sharples and J. D. McLeod

4. Materials for Construction of Small Craft:

   Part 1, Aluminum for Small Craft by W. J. Allsday
   Part 2, Ferro-Cement Construction by W. James
   Part 3, Steel as a Boatbuilding Material by R. Clark
   Part 4, The Use of Timber in Small Craft Construction by R. P. Sharphouse
   Part 5, Glass Reinforced Plastics by D. Wildman

5. Inflatable Craft by M.Webb
6. Navigational Aids for Small Craft by G. A. G. Brooke
7. Motor Yachts by K. H. C. Jurd
8. Fast Patrol Boats by Commander Peter Du Cane

These papers provide an excellent overview of the state-of-the-art of small craft design.

Spencer, J.S., "STRUCTURAL DESIGN OF ALUMINUM CREWBOATS", SNAME, Marine Technology, Volume 12, Number 3, July 1975.

Stevens, R., Carson, B. H., Krida, R.H., "TECHNOLOGICAL AND OPERATIONAL CONSTRAINTS IN ADVANCE MARINE VEHICLE DESIGN", AIAA/SNAME Advanced Marine Vehicles Conference, San Diego, California, February 1974.

Rapidly developing new technology presents us with the prospect of transitioning to a new Navy that in the coming decades will bear little resemblance to what we consider the conventional Navy of today. Such a transition will undoubtedly entail problems of considerable technological, economic, and operational importance. Three significant problem areas are found in the propulsion, manning, and service acceptance of advanced ship types. The significance of the propulsion problem lies in the need to continually update and imporve the technology. The matter of manning of advanced ships impacts heavily upon the concept of an all-volunteer Navy and the soaring percentage of the military budget allocated to manpower. With regard to service acceptance of advanced ship types, there is virtually no historic parallel for the tremendous change in overall naval operations that will be brought about by introduction of advanced marine vehicles into the Fleet. The Navy is occupied now with solving the technical problems involved in advanced marine vehicle technology; it must concurrently address itself to the problems attending its implementation.

Sugai, Kazuo, "ON THE MANEUVERABILITY OF THE HIGH SPEED BOAT", Bureau of Ships Translation No. 868, AD 463 211, 1964.

Sweger, G. A., "WHAT HAVE YOU DONE FOR THE FLEET SAILOR'S LIFE TODAY?" 11th Annual Symposium of the Association of Senior Engineers, March 1974.

This paper presents a picture of the U. S. Navy's personnel life-saving equipment program, how it is tailored to the requirements of emergencies inherent with fleet operations and how it helps to increase survival and recovery of seamen.

The discussion primarily deals with individual equipments that have been developed under the broad category of lifesaving systems, used to protect, escape or survive various threats to human life aboard ship. Sections of the paper are devoted to a brief look at historical development, what's presently in the fleet or coming soon, and some ideas for the future.

The author also briefly presents his opinions on the Navy's shortcomings in the lifesaving area and proposes a total systems approach to replace the present piecemeal approach of today.

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Timoshenko, S., "ELEMENTS OF STRENGTH OF MATERIALS", D Van Nostrand Company Inc., Princeton, N.J.

Toro, A., "SHALLOW WATER PERFORMANCE OF A PLANING BOAT", Symposium of Small Craft Technology, SNAME South East Section, 1969.

Traung, J.O., "FISHING BOATS OF THE WORLD", three volumes, Fishing News (Books) Ltd., 110 Fleet Street, London, E.C.4, England, 1955, 1960, 1967.

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United States Steel, "DESIGN MANUAL FOR HIGH STRENGTH STEELS".

University of Michigan, "SMALL CRAFT ENGINEERING", Notes used in the short course; available in three volumes:

Report 120, RESISTANCE, PROPULSION, and SEAKEEPING by Michelson, Koelbel, Savitsky, Appolonio

Report 121, SMALL CRAFT ENGINEERING STRUCTURES by Silvia, Scott, Michalopoulos

Report 122, PROPULSION BY THE INTERNAL COMBUSTION ENGINE by Woodward.

V

Van Gunsteren, F.F., "ANALYSIS OF ROLL STABILIZER PERFORMANCE", Sea Transport Engineering N.V., Surinamekade 5, Amsterdam, The Netherlands.

A short view of the mathematical formulation of the seaway and the ship motion response with special reference to rolling is given, where as measures of effectiveness of roll damping devices are briefly discussed.

Full scale rolling experiments with a motoryacht in still water and in waves are analyzed. The performance and design of fin-stabilizers is dealt with on the basis of experimental results and common hydrodynamic knowledge.

The use of rudders as roll stabilizers seems to be rather promising according to full scale motoryacht experiments.

Van Lammeren, P.A., et. al., "THE WAGENINGEN B-SCREW SERIES", SNAME, Transactions, 1969.

The Wageningen B-screw series have been extended gradually to 21 screw series having blade numbers ranging from 2 to 7 and blade-area ratios between 0.30 and 1.05. Recently, the existing screw series were correlated with the new screw series with an up-to-date fairing technique. This correlation was made by means of a regression analysis. Further, the influence of the Reynolds number (scale effect) on the test results was taken into account. For ship maneuvering studies, it is necessary to know the propeller thrust and torque characteristics over a wider range of operating conditions. Therefore, open water tests with B-series screws over the entire region of operation were carried out. In order to obtain systematic knowledge on the cavitation characteristics of the B-screw series in a uniform flow, tests have been conducted. The curves for cavitation inception were established and the influence of cavitation on propeller thrust and torque was determined.

Van Manen, J.D., "NON - CONVENTIONAL PROPULSION DEVICES", 13th ITTC, 1972.

Van Mater, P. and Dornak, H., "HYDRODYNAMIC CHARACTERISTICS OF BASIC PLANING HULL TYPES", SSSCD, Great Lakes Section, 1965.

Vibrans, F., "THE EFFECTS ON ENGINE LOAD FROM SMALL CHANGES IN PROPELLER DIMENSIONS", SNAME, Pacific Northwest Section, December 1973.

Vickers, Division of Sperry Rand, "INDUSTRIAL HYDRAULICS MANUAL", 935100-A, September 1970.

Von Gierke, H.E, "SHOCK AND VIBRATION BULLETIN 45, Part 2", June 1975.

W

Wagner, "RATIONAL METHODS FOR ENGINE RATINGS", SNAME, Gulf Section, October 1970.

Walker, A.C., "MARINE JET UNITS", Symposium on Small Craft, University of Southhampton, RINA, September 1971.

Marine jet units provide a useful means of propulsion for many special applications. In order to obtain the optimum performance when they are used it is essential to match them correctly to the operating conditions required. The following paper outlines the guide rules for this matching procedure, indicates the importance of the various elements, and draws a comparison between propeller and marine jet unit propulsive efficiency.

Wallin, "MARINE SEWAGE TREATMENT PLANTS - A GUIDE TO SELECTION", SNAME, San Diego Section, January 1973.

Weber, S., "A BIOLOGICAL ASSAY OF THE EFFECTS OF SUBMERGED ENGINE EXHAUST EMISSIONS", SNAME, Gulf Section, October 1970.

Whicker, L.F., and Fehlner, L.F., "FREE-STREAM CHARACTERISTICS OF A FAMILY OF LOW-ASPECT-RATIO, ALL-MOVABLE CONTROL SURFACES FOR APPLICATION TO SHIP DESIGN", DTMB, Report 933, December 1958.

Wilson, W.B., and Lombardi, P.V. ,"INTERIM PROCEDURE FOR THE CALCULATION OF HIGH PERFORMANCE SHIP ENDURANCE FUEL REQUIREMENTS", 11th Annual Symposium of the Association of Senior Engineers, January 1974.

This paper describes a procedure which can be used to arrive at the endurance fuel requirements for certain High Performance Ships. Factors are presented which correct for critical phenomena associated with the operation of these vehicles. Supporting methodology is presented which describes how and why these factors were established.

A step by step procedure is then given to assist the designer in performing the endurance fuel calculation. A plan for securing salient data is provided to aid in describing the deficiencies and gaps in the supporting data.

Wolk, H.L., and Tauber, J.F., M.D., "MAN'S PERFORMANCE DEGRADATION DURING SIMULATED SMALL BOAT SLAMMING", NSRDC Report 4234, January 1974.

A research program has been developed and preliminary data obtained on man's performance in a repetitive slamming environment such as would be encountered in a high-performance craft traversing rough seas. The Naval Ship Research and Development Center (NSRDC) slam simulator was used to test human volunteers in two series of laboratory-controlled studies that simulated ship slamming. The results indicate (1) that man's performance is degraded in a slamming environment (2) that the subjective reactions of the volunteers do not reflect their performance scores (3) that the test data are highly reproducible, and (4) that only minor muscular skeletal discomforts occurred during the test sessions. The report includes background material on man's known tolerance to single impacts and vibration.

Woodward, J.B., "WASTE HEAT DISTILLERS IN SMALL CRAFT - SOME ENGINEERING CONSIDERATIONS", SNAME, Great Lakes - Great Rivers Section, January 1972.

Woodward, J.B., PROPULSION BY THE INTERNAL COMBUSTION ENGINE", University of Michigan, Department of Naval Architecture Report 122, October 1971.

Woodward, J.B., "ARRANGEMENT OF SHIPBOARD PIPING BY DIGITAL COMPUTER", SNAME, Marine Technology, April 1974.

Woodward, J.B., et. al., "ELECTRIC POWER FOR SMALL COMMERCIAL VESSELS", SNAME Spring Meeting, April 1973.

Some of the principal items of electrical engineering that require the understanding of the marine designer are reviewed. These are voltage drops in distribution systems, voltage and frequency tolerances under steady and transient conditions, motor control, circuit protection, generator paralleling, and the relative merits of direct and alternating current systems. Emphasis is on systems for the small commercial vessel. Some of the design problems to be faced are also discussed. These are load analysis, circuit protection methods, choice of emergency power source, choice of alternating current versus direct current and choice of distribution systems. Two actual electric plants are described, one an alternating current system, the other direct current, aboard small passenger ferries of near-identical construction. It is seen that prominent features of the designs are dictated by special requirements of the vessel service.

Wyland, G.G., "SELECTION OF POWER PLANTS", SNAME, New York Metropolitan Section, January 14, 1967.

Y

Yeh, H.Y.H., "SERIES 64 RESISTANCE EXPERIMENTS ON HIGH-SPEED DISPLACEMENT FORMS", Marine Technology, Vol. 2, No. 3, July 1965.

The speed-length ratios of displacement-type surface ships in the past were limited to under 2.0. In order to perform projected tactical missions, however, the Navy needs ships of much higher speeds resulting in speed-length ratios of 2.0 or above. To gain information in this respect, 27 models of conventional hull forms designated "Series 64" were designed, constructed, and tested at the David Taylor Model Basin. This paper reports the results of the bare hull resistance tests of Series 64 models.